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KAUA‘I RESOURCE RECOVERY PARK FEASIBILITY STUDY

County of Kaua‘i
Department of Public Works
Solid Waste Division
4444 Rice Street, Room 275
Līhu‘e, Kaua‘i, Hawai‘i

April 2013

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Prepared for:

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Prepared by:

AECOM Technical Services, Inc.
1001 Bishop Street, Suite 1600
Honolulu, Hawaiʻi 96813-3698

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EXECUTIVE SUMMARY

The County of Kaua‘i (County) has identified co-locating a host of reuse, recycling, reduction, and recovery programs, activities, and facilities in one location as a key element in implementing its *Integrated Solid Waste Management Plan* (ISWMP) (Beck 2009). This facility, termed a resource recovery park (RRP), would be a ‘one-stop service center’ that is intended to be a comprehensive and integrated set of waste management programs and facilities to support maximization of waste reuse, recycling, and recovery. Providing a single centralized location where residential and commercial entities are able to conduct all of their recycling and waste diversion activities can provide a synergistic effect, and help promote reuse, recycling, and reduction of waste disposal. The RRP is intended to supplement the County’s existing decentralized waste management facilities and help maximize diversion of waste from the landfill.

This feasibility study (FS) explored existing waste diversion activities in Kaua‘i and in other counties of Hawai‘i, and generated waste quantity and composition data projected for a 20-year planning period. It then evaluated the various components and technologies currently available to the County, and explored the potential for co-locating a range of other facilities at the RRP that may further support resource recovery. Evaluation criteria included potential benefits to be provided, including potential for diversion of wastes from the municipal landfill, capital and operating and maintenance (O&M) costs, space requirements, and potential impacts to the community, including potential environmental and traffic impacts.

Central to a RRP is:

1. An Integrated Public Drop-off and Reuse Facility to promote increased diversion due to the convenience of a centralized one-stop service center with a relatively convenient and centralized location for the community to drop off materials intended for reuse or recycling

The Integrated Public Drop-off and Reuse Facility would be integrated with the following RRP components and facilities:

2. Recyclables and Waste Drop-off
3. Household Hazardous Waste Depot
4. Electronic Waste Depot
5. Metals Recycling Facility
6. Construction and Demolition Material Processing and Recycling Facility
7. Used Tire Processing Facility
8. Center for Hard-to-Recycle Materials
9. Reuse Center
10. Educational Center

In addition, the following facilities and technologies were evaluated as potential components of the RRP:

11. Materials Recovery Facility
12. Composting Facility
13. Anaerobic Digestion of Biomass
14. Biorefinery Facility

(Items 12–14: Only one of these alternatives would be implemented.)

15. Landfill Gas to Energy Facility
16. Waste to Energy Facility
17. Waste to Fuel Facility

(16–17:) These alternatives would not be implemented concurrently.

The results of the evaluations were used to provide a recommendation for each component/facility, as summarized in detail in Section 6, Table 38.

The amount and composition of waste generated on Kaua'i will likely change over time, as will the value of resources that can be recovered. Consequently, it may be appropriate to develop the RRP in stages in a manner that allows it to adapt to changing conditions. Additionally, in some instances, technologies may be identified that are not currently cost effective, but could become so in the future. Therefore, it may be appropriate to phase the development of the RRP in a manner that allows it to adapt to changing conditions, changing waste diversion and disposal patterns, changing technologies, and changing budgetary conditions. The design of the RRP should allow it to evolve over time in response to these future possibilities.

Two community meetings were held in January 2013 with the communities of Kaua'i in the early planning stages of a Resource Recovery (RRP), after publication of the Draft Feasibility Study (FS) to the County website. The purposes of the meetings were to:

- Present findings and preliminary recommendations of the Draft RRP FS; and
- Solicit public feedback on the Draft RRP FS.

Comments received during and after these meetings are summarized in Appendix F and have been incorporated into this report.

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ACRONYMS AND ABBREVIATIONS

°C	degree centigrade
°F	degree Fahrenheit
AD	anaerobic digestion
AECOM	AECOM Technical Services, Inc.
APTC	aerobically produced thermal compost
BTU	British thermal unit
C&D	construction and demolition
CCH	City and County of Honolulu
CED	covered electronic device
CFR	Code of Federal Regulations
CH_4	methane
CHP	combined heat and power
CO_2	carbon dioxide
County	County of Kaua‘i
CRC	certified redemption center
CV	net calorific value
cy	cubic yard
DO	dissolved oxygen
DOH	Department of Health, State of Hawai‘i
EPA	Environmental Protection Agency, United States
FS	feasibility study
ft	feet or foot
ft^2	square foot
FY	fiscal year
GID	Garden Isle Disposal
HAR	Hawai‘i Administrative Rules
hh	household
HHW	household hazardous waste
hr	hour
HVAC	heating, ventilation, and air conditioning
ISWMP	Integrated Solid Waste Management Plan
kg	kilogram
lb	pound
LLDPE	linear low-density polyethylene
LFG	landfill gas
LFGtE	landfill gas to energy
m^3	cubic meter
m/s	meter per second
MJ	megajoule
MM BTU	million British thermal units
MRF	materials recovery facility
MSWLF	municipal solid waste landfill
MW	megawatt
NOx	nitrogen oxide
OCC	old corrugated cardboard
O&M	operations and maintenance
PAYT	pay as you throw
PET	polyethylene terephthalate
PMRC	Puhi Metals Recycling Center
ppm	part per million
PVC	polyvinyl chloride

RDF	refuse-derived fuel
RFP	request for proposal
RRP	resource recovery park
scf	standard cubic foot
scfm	standard cubic foot per minute
sec	second
SRF	solid recovered fuel
SSO	source-separated organic
TPD	tons per day
TPH	tons per hour
TPY	ton per year
TS	total solids
U.S.	United States
WtE	waste to energy
yr	year

1.0 INTRODUCTION

1.1 BACKGROUND – WASTE DIVERSION GOALS

In 1991, the State of Hawai'i set a goal for each county to divert 50 percent (%) of its waste stream from landfill disposal by 2000. In 2005, the County of Kaua'i (County) reported a diversion rate of 25%. In 2009, the County published its *Integrated Solid Waste Management Plan* (Beck 2009) (herein referred to as the ISWMP), which identified and recommended a range of programs, activities, and facilities to be implemented in order to maximize waste diversion. The ISWMP is a fundamental waste policy document for the County, and its recommendations and methodologies are employed herein. The ISWMP projected a diversion rate of 35% by 2013, a goal adopted by the County in 2009–2010. Currently, the County estimates that its diversion rate is approximately 31%.

In order to maximize its waste diversion rate, the County has adopted zero-waste principles that promote the highest and best use of materials to eliminate waste and pollution by emphasizing a closed-loop system of production and consumption. Zero-waste principles are consistent with the County's commitment to island-wide sustainability. The principles of a zero-waste policy and the zero-waste diversion goal were formally adopted by the Kaua'i County Council in October 2011. Pursuant to this policy, the County has committed its legislation, policies, rulemaking, and actions to incorporate zero-waste management principles to the extent possible and feasible, with the specific goal of implementing the County's ISWMP and achieving the waste diversion goals in a cost-effective manner. As part of this process, the County adopted a longer-term waste diversion goal of 70% by 2023.

1.2 THE RESOURCE RECOVERY PARK CONCEPT

The County has identified a key element to achieving its waste reduction goals, implementing the ISWMP, and furthering its zero-waste policy: co-locating a host of reuse, recycling, and recovery programs, activities, and facilities in one location. The resource recovery park (RRP) would be a 'one-stop service center' for reuse, recycling, and other compatible activities that promotes maximizing waste reduction by accepting a broad range of materials that might otherwise be disposed of in the landfill.

This document advances the design of the RRP, by evaluating the various technologies currently available to the County. The analyses in this feasibility study (FS) are guided by the principles adopted by the County as part of its ISWMP in pursuit of increased diversion from disposal, which includes minimization of cost, facilitation of business development, and increased public participation, among others. In addition, the County has identified the potential opportunity to locate a range of other facilities at the RRP that may further support resource recovery. The RRP is expected to be located near the new long-term municipal waste disposal facility when it is identified and approved, for economy of cost and integration of operations.

A RRP is a facility where:

- Larger quantities of wastes that *are* managed by curbside collection can be received and processed for reuse, recycling, or recovery.
- Wastes that *are not* collected curbside can be received directly from residents or businesses to provide an outlet for the public to dispose of large-volume or bulky non-hazardous waste materials, and small-volume difficult-to-manage or hazardous waste materials.
- Alternatives are provided to support the reuse and recovery of a broader range of valuable materials.
- Facilities and services are made available to commercial establishments or private waste haulers that collect their waste with the means to achieve their own diversion goals or meet County policies/regulations such as disposal bans. These County-provided facilities are

generally intended to supplement and complement, not compete with, existing private-sector facilities.

The RRP is intended to be a comprehensive and integrated set of waste management programs and facilities to support maximization of waste reuse, recycling, and recovery. It is anticipated that the RRP will offer a number of additional benefits to the County, possibly including energy production and job creation. The success of the RRP will ultimately be measured by the quantity of waste that is diverted from disposal, extending the life of the municipal landfill site.

Generally, a RRP can range in scope from a small community-based facility, with select processes specific to that community's waste profile, to a large-scale complex that integrates all aspects of waste management including collection, separation, and processing of a host of material streams. A RRP is typically established to accept recoverable materials directly from the public, the commercial sector, and potentially from private contractors; however, a RRP can also be developed to incorporate processing technologies or facilities required to prepare materials for secondary markets. The use of a RRP as a material processing facility may in turn provide an opportunity for businesses to co-locate at the RRP to utilize recovered materials or deliver complementary services.

This FS presents best estimates of diversion potential for each technology or process under consideration for use at the RRP, and costs for developing, operating, and maintaining that technology or process. A wide range of options for minimizing landfill waste are available; the contribution of each option to the overall goal varies, and some estimates are necessarily imprecise. Potential options, some of which are presently offered by the County, range from education and awareness to some form of processing and utilizing materials that might otherwise be landfilled as a resource. A number of technical alternatives exist that could significantly decrease the quantity of residual waste remaining for landfilling. A number of the alternatives also overlap in terms of their requirement to utilize the same portion of the waste stream as a feedstock. Therefore, this FS reviews an extensive list of potential technologies for their cost, implementability, and diversion potential and other benefits, to support a cohesive and integrated strategy for design of the RRP.

1.3 Centralized RRP versus Decentralized Facilities

Some communities have achieved their waste diversion goals by developing a network of decentralized waste management facilities. On Kaua'i, such decentralized waste management facilities can include a combination of public- and private-sector facilities distributed throughout the entire waste-shed area (i.e., the island). Presently, the County is employing a decentralized approach to support waste diversion through the use of contractor and County operated facilities, such as the Kaua'i Resource Center, the existing greenwaste composting facilities, waste transfer stations, and the Kaua'i Recycles Drop Bin Program. In the future, the RRP can be designed and adapted to support these decentralized facilities, as well as the planned curbside collection of recyclables and greenwaste, and policies that the County may implement to facilitate diversion. The existing network of privately and publicly owned/operated decentralized facilities may also be adapted in the future to better complement and supplement the overall, evolving recycling needs of the island.

Generally, benefits of decentralized waste management facilities may include:

- Locating facilities closer to the point of generation for certain materials, thereby potentially reducing collection haul time and costs, and increasing convenience for some users.
- Locating facilities closer to major transportation facilities (e.g., roadways, shipping terminals).

Potential problems or insufficiencies of decentralized waste management facilities that the proposed RRP may help to alleviate include:

- Inability to take advantage of economies of scale, which may result in less (or no) diversion of some waste streams.
- Redundancies can result in increased capital, labor, and maintenance costs.
- Requiring the public to drive to several facilities to recycle and reduce their waste.
- Creating obstacles for commercial entities to maximize their waste diversion.
- More difficult to adapt several facilities to complement potential future policies.
- No synergies between facilities to support sharing of resources and creation of joint business opportunities.

The RRP need not replace, nor be considered in opposition to, a decentralized approach; instead, the RRP can enhance such an approach. Specifically, the County has the opportunity to take advantage of the positive aspects of decentralized facilities and processes, including those already in place on the island, while realizing the potential of a centralized facility to provide comprehensive services and maximize waste diversion. A properly designed and managed RRP, along with the County's existing and future decentralized facilities, is the best route to truly *integrated* solid waste management.

1.4 Phasing of the RRP

It may be appropriate to phase the development of the RRP in a manner that allows it to adapt to changing conditions, including the actual needs at the time of development. Factors that could determine the decision to implement facilities as part of the RRP may include:

- The amount and composition of waste generated on Kaua'i will likely change over time.
- The value of recovered resources and the availability of end markets will change over time.
- Technologies that are not currently cost effective may become so in the future, and new technologies may become commercially viable.
- The availability of existing services already provided on Kaua'i (e.g., metal processing facility in Puhi, composting facilities in Puhi and Kīlauea, C & D facility in Līhu'e, etc.) may be sufficient at the present time, and therefore may not need to be duplicated at the RRP at this time; however, this could change in the future.
- Economic conditions and the financial ability of the County to fund the costs of both the new landfill site and the RRP may require that construction of some elements of the RRP be deferred to subsequent years, to reduce the County's financial burden over time.

Therefore, the design of the RRP should allow it to evolve over time in response to these future possibilities.

1.5 Previous Studies

The County of Kaua'i has previously undertaken various studies and analyses that were relied upon by the analyses in this FS. The studies most significantly affecting this FS are:

- *Integrated Solid Waste Management Plan*, County of Kaua'i (Beck 2009)
- *Centralized Composting Facility Master Plan*, County of Kaua'i (Beck 2008)
- *Pilot Curbside Recycling Report*, Kaua'i County (SAIC 2011)

The ISWMP provides a recommended action plan for the County to maximize waste diversion by implementing cost-effective integrated solid waste management components. The concept of the RRP has evolved from this plan by proposing to combine the various components into a single integrated location. As identified in the ISWMP, development of a materials recovery facility (MRF) and a composting facility are two of the key infrastructure components to maximize waste diversion.

The *Pilot Curbside Recycling Report* assisted in defining the County's proposed approach to recyclables collection, and in providing an estimate of the anticipated effectiveness of such a program, which in turn defines the size and type of processing required at a MRF. The Composting Plan outlines a proposed approach for development of a centralized composting facility to serve the County's needs.

1.6 PUBLIC OUTREACH

Two community meetings were held in January 2013 with the communities of Kaua'i in the early planning stages of the RRP, after publication of the Draft FS to the County website. The purposes of the meetings were to:

- Present findings and preliminary recommendations of the Draft RRP FS; and
- Solicit public feedback on the Draft RRP FS.

Comments received during and after these meetings are summarized in Appendix F and responses have been incorporated into this report.

Additional opportunities for public comments are being provided as part of the ongoing Environmental Impact Statement for the new landfill.

2.0 EXISTING WASTE DIVERSION ACTIVITIES

This section provides an overview of the current waste management programs related to waste reuse, recycling, and recovery provided by the County of Kaua‘i, as well as background information for O‘ahu, Maui, and Hawai‘i island to assist in identifying potential opportunities for partnering or cost-sharing for any specific program or technology as part of the RRP.

2.1 COUNTY OF KAUA‘I

The County provides residents with several options for the management of various wastes. Generally, recycling and waste disposal options target residents rather than commercial and non-residential waste generators. The County estimates that 45% of municipal wastes are generated by residential sources. Recycling programs offered by the County are managed by the County and contracted to private contractors. Non-residential waste generators generally use private contractors for their recycling and waste disposal needs.

The County owns the Kaua‘i Resource Center (a waste reduction and recycling center) located in Līhu‘e near the airport and four transfer stations located in Hanalei, Kāpa‘a, Līhu‘e, and Hanapēpē. The operation and maintenance of the Kaua‘i Resource Center and eight recycling drop-bins located throughout the island are contracted out to a private operator. Collectively, the existing decentralized recycling programs accept various types of materials for recycling including appliances, scrap metal, green waste, motor oil, motor oil filters, tires, propane tanks, and used cooking oil, thereby providing residents with diversion options in lieu of a limited number of private recycling vendors. The County also owns the Kekaha Municipal Solid Waste Landfill (MSWLF), which is operated by Waste Management Inc., under contract to the County.

The County formerly owned the Puhi Metals Recycling Center (PMRC), the island’s primary metal recycling facility. PMRC is now privately owned and operated by Grove Farms Inc. and Resource Recovery Solutions LLC, respectively. As a privately operated facility, the PMRC accepts recyclable metal goods from both residential and commercial sources.

2.1.1 General Household Recyclables

General household recyclable items (e.g., cardboard, newspaper, mixed paper, glass, plastic, aluminum cans, and [recently] steel cans) are accepted for recycling at the Kaua‘i Resource Center and through the Kaua‘i Recycles drop bin program at the eight drop-bin locations throughout the island. The only plastics accepted are #1 polyethylene terephthalate (PET) and #2 high-density polyethylene (HDPE). Other forms of plastic (i.e., #3–#7) are not currently accepted because of their relatively low market value and lack of processing space to store large volumes of materials prior to shipping. Paper, glass, aluminum containers, and recyclable plastic are processed by a single contractor on Kaua‘i. Garden Isle Disposal (GID), the main private solid-waste hauler on the island and owner of the only recycling processing facility on Kaua‘i, is contracted by the County and private entities to collect and haul residentially and commercially generated paper, glass, aluminum, and plastic materials for recycling. Excluding limited occurrences of commingling and contamination, GID generally receives source-separated recyclables, and therefore does not have or require mechanized sorting equipment.

The County-funded Kaua‘i Recycles drop-bin program operates at eight sites throughout the island, in Hanalei, Kāpa‘a, Līhu‘e, Po‘ipū, Lāwa‘i, ‘Ele‘ele, Waimea, and Kekaha. Each drop-bin consists of one large multi-compartment roll-off and three bins. The County rents the drop-bins from GID for collection of plastics (#1 and #2), aluminum and steel cans, corrugated cardboard, glass, mixed paper, and newspaper from residents. Each site is designed for residents to self-sort materials upon drop-off, enabling GID to process the materials separately. GID hauls the drop-bins to their facility on a current hauling schedule of 160 hauls per month, or as required. The County indicated that some drop-bins are hauled as many as 25 times per month, depending on usage. The volume of materials collected in fiscal year (FY) 2011 through the Kaua‘i Recycles drop-bin program was approximately 1,640 tons. An additional 1,080 tons of recyclables were collected at the Kaua‘i Resource Center during FY2011. It is noted that the Kaua'i Resource Center includes a HI-5 redemption center, which increases the volume of materials collected at that site due to financial incentive. Residents do not receive a deposit fee for recycling at the drop-bins. A summary of the recyclables collected is shown in Table 1.

Table 1: Quantities (tons) of Recyclable Materials Collected by the Kaua'i Recycles Drop-bin Program and Kaua'i Resource Center in FY2011

Source	Cardboard	Newspaper	Mixed Paper	Glass	Aluminum	Plastic	Total Quantity (Tons)
Drop-bins	695	199	423	275	0.55	47	1,640
Kaua'i Resource Center	155	20	5	712	83	103	1,078
Total Tons	850	219	428	987	84	150	2,718

Note Kaua'i Resource Center glass, aluminum, and plastic quantities include HI-5 redemption containers.

In addition to residential sources of materials, GID also collects recyclable materials from commercial sources. Some United States (U.S.) mainland–based stores, such as Kmart, manage their own recyclables; however, most commercially generated recyclables on Kaua'i are managed through GID. All materials are source-separated before collection, and therefore GID performs minimal processing of materials. Any separation of materials required due to commingling or contamination is done manually. GID's disposal facility is located in Līhu'e, near Nāwiliwili Harbor. All materials are baled and shipped directly to the U.S. mainland or markets in Asia for recycling into new products.

For FY2012, the County contracted with GID for the amount of $531,336 to haul recyclables and maintain the drop-off sites at the eight drop-bin locations. The contract has the option for on-call hauling up to 36 times per year at each drop-bin. Also included in the contract are additional items for monthly pickup of recyclables from County offices and monthly recycling promotional activities. As specified in the contract, such promotional activities are intended to "promote and increase public awareness of the importance and need for recycling and other related activities."

2.1.1.1 Commodity Prices

The re-sale value of materials collected for recycling is an important factor in evaluating the feasibility of technologies that may be employed at the RRP. In general, most materials collected for recycling in Hawai'i that have value are shipped and sold to markets in Asia or the U.S. mainland, where the materials are processed into usable goods. Due to limited demand, an insufficient number of businesses in Hawai'i process materials into usable goods to recommend pursuing such partnerships in Hawai'i.

Several local companies sell materials for out-of-state recycling. Commodity prices for materials sold by GID and RRR Recycling Services Hawaii in FY2011 are presented in Table 2. Values shown in the table reflect shipping costs, which effectively reduce the overall value of a material. Additionally, southwest U.S. commodity prices compiled by the publication *Waste & Recycling News* in October 2012 are shown for comparison purposes. Other companies on O'ahu, Maui, and Hawai'i island market recyclable materials out-of-state; however, the commodity prices were not readily available for inclusion in this report. As discussed in Section 2.1.1, GID collects recyclable materials on Kaua'i through the County drop-bin program and from commercial sources. With the exception of glass and aluminum, GID hauls, bales, and ships the materials to markets in Asia or the U.S. mainland. HI-5 glass (see Section 2.1.3) is crushed, shipped, and sold in California, while non-deposit glass is crushed and used on Kaua'i as backfill in construction projects. Aluminum is sold in Alabama, Tennessee, and Kentucky. RRR Recycling, located on O'ahu, also manages drop-bins, and processes, ships, and sells recyclable materials collected through the City and County of Honolulu's residential curbside recycling program. Materials are hauled to the RRR Recycling facility, where a semi-automated MRF sorts the single-stream mixed recyclables. RRR then ships and sells the materials in markets in Asia or the U.S. mainland. In FY2011, RRR reported collecting 20,971 tons of single-stream mixed recyclable materials (DES 2011). Schnitzer Steel Hawaii reported the value of mixed scrap metal to be in the order of $115 per ton.

Table 2: Commodity Prices

Material Type	$/ton		
	GID [a]	RRR Recycling	Southwest U.S. Mainland [b]
Paper	$90–$105	$115–$160	$70
Corrugated Cardboard	$130	$140–$190	$120
Plastic #1	$465	$360–$670	$540
Plastic #2	$500	$160–$345	$540
Aluminum	$1,360	$1,060–$1,700	$1,480
Bi-metal	n/a	$100–$180	n/a
Glass	$7	–$100 to –$105 [c]	$14

n/a not available
[a] All values shown for GID and RRR Recycling are from FY2011, except for GID aluminum, which is FY2012.
[b] Source: Waste & Recycling News, commodity prices as of October 2012.
[c] Shipping costs exceed market value (DES 2011).

2.1.2 Residential Curbside Recyclables Collection Pilot Program

Between September 2010 and August 2011, the County conducted a pilot curbside recycling program in the Līhu'e-Puhi area. During the pilot program, recycling bins were supplied to 1,300 residences (670 in the Puhi area and 630 in central Līhu'e), and unsorted ("single-stream") recyclable materials were collected every second week. The collected recyclables were sorted by hand at a private contractor's recycling facility, since mechanical separation of commingled recyclables is not currently available on Kaua'i.

A report evaluating the pilot program (SAIC 2011) provided the following select findings and recommendations:

- On average, 28.5 pounds of recyclables per month were collected from each household.
- The composition of collected materials was consistent with materials collected by other U.S. curbside single-stream recycling programs reviewed by SAIC.
- State deposit beverage container program (see Section 2.1.3) materials represented a low percentage of materials collected.
- Paper products composed more than 70 percent of materials collected.
- A fully expanded curbside recycling program would require a MRF that can process single-stream recyclable materials.
- An island-wide curbside recycling program would initially collect a projected 3,100 tons per year (TPY) of materials.

The report estimated that approximately 3,700–4,800 TPY of materials could be collected through a curbside program, compared to the 1,600 TPY currently being collected through recyclables collection at the Kaua'i Resource Center and the drop-bins. During the pilot program, drop-bins at the Kaua'i Resource Center and the Kauai Recycles drop-off bins experienced 20% and 6% declines in deliveries, respectively, compared to the previous year. An island-wide curbside recycling single-stream collection program is expected to be implemented once a suitable MRF is available.

2.1.3 State Deposit Beverage Container Program

While not a County program, the State's Deposit Beverage Container program supports recycling and landfill diversion on the island of Kauaʻi. The program was implemented in January 2005 to encourage recycling, reduce litter, and promote diversion of recyclables from the landfill. Under the law (Hawaiʻi Administrative Rules [HAR] Title 11, Chapter 282 Deposit Beverage Container Recycling), administered and regulated by the Hawaiʻi State Department of Health (DOH) Solid and Hazardous Waste Branch, a $0.05 deposit fee and $0.01 container fee were added to each glass, polyethylene, terephthalate, high-density polyethylene, and metal beverage container less than or equal to 68 fluid ounces and intended for consumption in Hawaiʻi. The program is referred to as "HI-5" based on the $0.05 deposit paid on specified beverage containers. Containers may be redeemed for $0.05 per container at commercially operated certified redemption centers (CRCs). CRCs receive a $0.02–$0.04 handling fee per container from the State for operational and shipping costs for containers that are transported out-of-state. Unredeemed container and deposit fees go toward other costs to support the State-managed Deposit Beverage Container program (DOH 2007).

Individuals are paid $0.05 per container by CRCs upon collection. The redemption centers then submit records to the State, and are reimbursed the $0.05 redemption fee plus a standard container-handling fee. On Kauaʻi, handling fees are $0.03 per container for aluminum, bimetals, and plastic, and $0.04 per container for glass. In FY2011, State HI-5 payments for beverage containers from Kauaʻi totaled more than $2.25 million in redemption deposits and more than $1.45 million in handling fees (i.e., aluminum $642,870; bi-metal $2,510; glass $401,150; and plastic $403,860).

The Hawaiʻi State DOH Solid Waste Branch regulates the private redemption centers and companies that sell HI-5 materials. All eight CRCs in the County are privately operated.

- Kauaʻi Community Recycling Services operates four facilities in Kekaha, Kilauea, Kāpaʻa, and Kōloa. The Kekaha and Koloa facilities are contracted by the County using State Deposit Beverage Container program funding. The two sites are open to the public 2 days per week.
- Reynolds Recycling operates three facilities in Nāwiliwili Harbor, Kapahi, and Lāwaʻi.
- GID operates one facility (Kauaʻi Resource Center) in Līhuʻe. The redemption center is contracted to GID by concession, and includes a recycling drop site for residential and commercial non-HI-5 recyclables.

GID is currently the only company on Kauaʻi with the capability to process, weigh, and ship used beverage containers to market, and therefore all materials ultimately go through them before being sold in out-of-state markets. GID receives the materials from the CRCs, then bales and containerizes them for shipment directly to Asia or U.S. mainland markets. Currently, GID accepts aluminum and plastic from the redemption centers for no charge and charges 5 cents per pound to accept and process glass. The redemption centers keep the container handling fees, while GID keeps all capital generated from the sale of the HI-5 materials. The commodity prices that GID brokered the HI-5 beverage containers for in FY2011 are provided in Table 2.

Statewide, the Deposit Beverage Container program had redemption rates of 76% in FY2011, 79% in FY2009, and 72% in FY2008 (County-specific redemption rates are not kept). Table 3 shows the number of containers redeemed by material type for Kauaʻi and the other counties in FY2011.

Table 3: Total HI-5 Containers Recycled by Material Type in FY2011, by County

County	Aluminum	Bi-metal	Glass	Plastic	Total
Kaua‘i	21,429,026	83,672	10,028,762	13,462,158	45,003,618
CCH (O‘ahu)	195,207,007	445,326	76,636,576	148,468,950	420,757,859
Maui	48,419,986	452,212	22,337,851	35,942,757	107,152,806
Hawai‘i	55,610,499	234,334	22,498,048	35,601,593	113,944,474
Total	**320,666,518**	**1,215,545**	**131,501,238**	**233,475,458**	**686,858,757**

CCH City and County of Honolulu

Based on the current DOH weight rates, the tonnage of each type of material collected on Kaua‘i by CRCs in FY2011 can be roughly estimated as follows:

- Aluminum: 335 tons
- Bi-metal: 7 tons
- Glass: 2,089 tons
- Plastic: 299 tons
- Total: 2,731 tons

2.1.4 Greenwaste

Greenwaste intended for recycling is accepted at the four County transfer stations and Kekaha MSWLF. The greenwaste is processed on-island, where it is shredded into mulch product for use as ground cover or as carbon base for composting. Greenwaste from commercial sources is required to be separated from other waste types, cut to less than 8 feet in length prior to drop-off at the transfer stations or Kekaha MSWLF, and is limited to small haulers (i.e. pickup trucks). Larger commercial greenwaste generators are instructed to haul greenwaste directly to Heart and Soul Organics or Kaua‘i Nursery and Landscaping, two of three privately-owned greenwaste composters listed below. Residentially generated greenwaste does not have any size requirements for acceptance. In FY2011, the County collected 18,740 tons of residential greenwaste.

The County contracts three private companies to manage greenwaste collected by the County:

- Heart and Soul Organics LLC, based in Kilauea
- Kaua‘i Nursery and Landscaping, based in Līhu‘e
- Shredco LLC, with operations at Hanapēpē Transfer Station and Kekaha MSWLF

Greenwaste collected at the four County transfer stations and Kekaha MSWLF is dispatched as follows:

- Hanalei Transfer Station: The County hauls 100% of the collected greenwaste to Heart and Soul Organics in Kilauea, which shreds it and then sells compost to commercial developments.
- Līhu‘e Transfer Station: The County hauls 100% of the collected greenwaste to Kaua‘i Nursery and Landscaping in Līhu‘e, which shreds it and generally uses the mulch in its nursery operations.
- Kāpa‘a Transfer Station: The County hauls two-thirds of the collected greenwaste to Heart and Soul Organics in Kilauea and one third of it to Kaua‘i Nursery and Landscaping in Līhu‘e, where it is processed as described above.

- Hanapēpē Transfer Station: Shredco conducts onsite shredding and hauls 90% of it to a private parcel in Kekaha, where it is mixed into the soil. The remaining shredded greenwaste is reserved for residents and available free of charge.
- Kekaha MSWLF: Shredco conducts onsite shredding and hauls 50% of the shredded greenwaste to a private parcel in Kekaha for mixing into the soil. The remaining shredded greenwaste is reserved for residents and available free of charge.

The County has also previously delivered mulch to State agencies and non-profits upon request.

Terms of the County contracts with the three greenwaste companies include the following:

- Heart and Soul Organics (FY2011) is paid $9.92 per cubic yard (cy) to shred and dispose of an estimated 10,473 cy of greenwaste that is hauled by the County from their Hanalei and Kāpaʻa transfer stations to Heart and Soul Organics in Kilauea.
- Kauaʻi Nursery and Landscaping (FY2011) is paid $9.92 per cy to shred and dispose of an estimated 5,236 cy of greenwaste that is hauled by the County from their Kāpaʻa and Līhuʻe transfer stations to Kauaʻi Nursery and Landscaping in Līhuʻe.
- Shredco (FY2012) is paid to shred greenwaste collected at the Hanapēpē transfer station and Kekaha MSWLF on site and then haul and dispose of the mulch at a private facility. Table 4 summarizes terms of the Shredco contract with the County for FY2012.

Table 4: Shredco Contract Estimated Quantities and Prices for FY2012

Location	Estimated Shredded Quantity	Unit Shredded Price	Estimated Haul Quantity	Unit Haul Price
Kekaha Debris Recycling Station [a]	5,216 tons	$40.00 per ton	2,608 tons	$30.00 per ton
Hanapēpē Transfer Station [b]	32,000 cy	$8.50 per cy	28,800 cy	$5.60 per cy

Notes:
[a] Four mobilizations were anticipated at a unit price of $2,000 each.
[b] Eight mobilizations/demobilizations were anticipated at a unit price of $2,000 each.

2.1.5 Household Hazardous Waste

The County offers an annual Household Hazardous Waste (HHW) collection event for a wide range of non-regulated residentially generated HHW materials, such as oil-based paints and solvents, non-regulated liquid wastes, household batteries, lead-acid batteries, mercury, and fluorescent light bulbs. Commercial and institutional hazardous wastes must be managed through a private hazardous waste disposal contractor. In 2012, the County contracted Enviroservices & Training Center LLC to conduct HHW collection events at no charge to residents. Enviroservices conducts similar HHW collection events on Hawaiʻi island and Oʻahu. Based on a contract with the County, Enviroservices charged the unit prices shown in Table 5. In addition to the unit costs, the contract also specified a $29,900 lump-sum mobilization/demobilization cost.

Table 5: Enviroservices Contract Costs for HHW Disposal, FY2012

Item	Estimated Quantity	Unit Price
Automotive lead-acid batteries	200 batteries	$1.00
Industrial lead-acid batteries	10 batteries	$1.00
Oil-based paints and ignitables	30 55-gal drums	$250.00
Other non-regulated HHW	30 55-gal drums	$390.00
Mercury	4 5-gal drums	$1.00
Fluorescent bulbs	500 bulbs	$1.10

Enviroservices collected HHW at four locations in 2012. Typically, events are held in Kāpa'a and Hanalei on Saturday and then in Līhu'e and Hanapēpē the following day, Sunday. Following the collection events, batteries are transported to Napa Auto Parts on Kaua'i for recycling, lamps are processed on site using a lamp vacuum that crushes the lamps and removes enough mercury to allow for disposal at Kekaha MSWLF, and mixed wastes (e.g., mercury, flammables, and other hazardous liquids) are transported to O'ahu, bulked, and then shipped to the U.S. mainland for final disposal in a hazardous waste landfill.

The County also offers a battery recycling program at the Kaua'i Resource Center. The center accepts lithium, nickel-cadmium, and alkaline batteries. The program does not accept car and uninterrupted power supply (UPS) batteries; these types of batteries are collected year-round by retailers. Retailers are required by State law to accept old car batteries when customers purchase new ones. Napa Auto Parts in Līhu'e accepts old car and UPS batteries for no charge from residents.

2.1.5.1 Used Motor Oil Diversion

Motor oil is accepted for recycling at the County's four transfer stations and Kekaha MSWLF. Only motor oil from residential oil changes is accepted. To encourage such recycling, the County offers residents free motor oil drainers. The County contracts Unitek Solvent Services, Inc. to pick up and dispose of the motor oil. Unitek ships the oil to O'ahu, where it is burned as fuel. For FY2013, the County projected a budget of $55,000 for motor oil recycling.

Motor oil filters are accepted for recycling at the four County transfer stations, but not at Kekaha MSWLF.

2.1.5.2 Used Cooking Oil Diversion

The County currently offers a used cooking oil recycling program. Residentially generated used cooking oil is accepted at the Līhu'e and Hanapēpē Transfer Stations. The cooking oil is then transported by Kauai Grease Trap to Kauai Farm Fuels in Hanapēpē, where it is processed and converted into biodiesel.

2.1.6 Automobiles, Used Appliances, and Scrap Metal

Pursuant to HAR Title 11 Chapter 58.1, automobiles, white goods, and used tires cannot be accepted at any Subtitle D landfills in Hawai'i. The County contracts Resource Recovery Solutions LLC to collect and process scrap metals, vehicles, propane tanks, and white goods (enamel-coated electrical and mechanical household appliances made primarily of metals) at the PMRC. The PMRC accepts the materials for free from residents. Most commercially hauled materials are also accepted free of charge, except for white goods such as refrigerators and air conditioning units that contain refrigerant. The facility charges $20 per unit for commercially hauled refrigerators and air conditioning units because Freon (i.e., chlorofluorocarbons) and halogenated oils must be drained and collected before further processing. Residential sources of white goods are accepted at the four transfer stations and Kekaha MSWLF for no charge. The County contracts the hauling of the white goods to the PMRC. Unitek Solvent Services, Inc. is contracted by Resource Recovery Solutions to dispose of the removed hazardous liquids, which it does either on O'ahu or the U.S. mainland.

The PMRC operates as a collection area and limited processing facility. Scrap metals and white goods are baled into cubes and temporarily stored before shipping. Vehicles and other mechanized equipment are drained of oils and petroleum before being shipped, but are not stripped of fabrics and other non-metal materials. Scrap metal, white goods, and vehicles are ultimately sent by barge to Schnitzer Steel Hawaii Corporation (formerly Hawaii Metal Recycling) located in Kapolei, O'ahu. Schnitzer Steel removes non-metals, such as insulation and fabrics, shreds the metals, and sorts the aluminum, steel, and other recyclable metals. Non-metals are disposed of as solid waste on Oʻahu. Recovered metals are marketed overseas by Schnitzer.

Resource Recovery Solutions is a joint venture between Grove Farms, the landowner of the PMRC, and Refrigerant Recycling, Inc., which operates the facility. Under their contract, the County pays Resource Recovery Solutions $46,500 per month to operate the PMRC. The facility reported collecting the following quantities in FY2011:

- Automobiles: 1,802 tons
- White goods: 968 tons
- Scrap metal: 1,899 tons
- Propane tanks: 1,068 tanks

2.1.7 Electronics and Electrical Waste

The Hawaii Electronic Waste and Television Recycling and Recovery Law (HAR Title 19, Chapter 339D) requires manufacturers of televisions, computers, printers, and monitors to provide recycling programs for the materials they generate. Currently, manufacturers do not provide feasible electronics recycling opportunities on Kauaʻi. The majority of manufacturers only offer “mail back” programs, where users must package and ship items for recycling. The effort required to mail large televisions and other items covered under the law discourages residents from using the recycling program. Therefore, in order to increase electronics recycling, the County has had to subsidize recycling programs since the law went into effect.

The County has conducted competitive procurements to provide periodic recycling events open to residents and businesses. The cost of contracted services has ranged vastly, from $126,485 for a 2-day event in October 2011 to $0 for a 4-day event in June 2012. Electronics collected during past events have been shipped to mainland recycling facilities, where they are shredded and then processed for steel, aluminum, copper, circuit boards, plastics, and glass to be used by smelting processors in place of raw materials. Besides County events, Kauaʻi residents have few other options for electronics. Manufacturers have also sponsored events without County support or coordination; however, those types of events have been limited. Kauaʻi United Way and Verizon Wireless accept old cell phones. Kalaheo School accepts other high-end electronic equipment, such as inkjet and toner cartridges, laptop computers, digital cameras, and MP3 players, during events held every other year.

The County currently sits on the Hawaii Electric Device Recycling Task Force and is working to modify the legislation to improve programs on Kauaʻi and mandate that manufacturers provide more convenient electronic recycling events for island residents on a regular frequency. Should the law be successfully amended, County subsidies for events will not be required in the future. The RRP could provide a convenient central location for recycling, which manufacturers could utilize to perform ongoing collections.

2.1.8 Fluorescent Lights

Compact fluorescent light bulb recycling is offered at the Līhuʻe Home Depot retail store, and residentially generated fluorescent tubes are collected as part of the County’s annual HHW events. Disposal options for tubes less than 3 feet are available to residents and small-quantity commercial generators at any transfer station. Tubes longer than 3 feet can be disposed of at the Līhuʻe Transfer Station or at Kekaha MSWLF. Large quantity commercial generators need to hire a hazardous waste disposal company to dispose of old fluorescent lighting.

2.1.9 Used Tires

The County accepts used tires free of charge from residents at all transfer stations and at the Kekaha MSWLF. Residents can bring up to eight auto and light truck tires per year or four truck and high-performance tires per year. Non-residential tires are not accepted by the County, but accepted for a fee at PS&D Tires.

The County contracts Unitek Solvent Services, Inc., located on O'ahu, to load, haul, and ship used motor vehicle tires for off-island recycling or disposal. Under the FY2012 contract with the County, Unitek hauls tires from six County facilities (i.e., the four transfer stations, Kekaha Debris Recycling Center at the Kekaha MSWLF, and County Public Works Automotive Repair Shop in Līhu'e) on a weekly basis. As the main tire recycler in the State, Unitek provides similar tire recycling services on O'ahu, Maui, and Hawai'i island to both public and private entities. In FY2011, the County reported that Unitek collected 13,699 used tires (including motorcycle, passenger car, large truck, and bus tires). The fee charged by Unitek is dependent on tire type and size, ranging from $2.34 to more than $220 per tire.

All tire companies in Hawai'i are required to accept used tires in exchange for new one's purchased (HRS Section 342I-23). PS&D Tires was contacted during research for this RRP FS, and indicated that they contract Unitek for disposal of their used tires. Other tire companies on Kaua'i presumably similarly contract Unitek for tire disposal.

Unitek transports the tires to O'ahu, where they are either shredded and burned for fuel to generate electricity at the AES Hawaii coal-fired power plant in O'ahu's Campbell Industrial Park, or ground into crumb rubber used for landscaping.

2.1.10 Construction and Demolition Waste

Construction and demolition (C&D) debris is generally accepted at Kekaha MSWLF, for a tipping fee of $90 per ton for commercial haulers and no fee for residents, where it is landfilled along with general waste. The $90 per ton tipping fee is the same as that for other types of solid waste hauled to the landfill by commercial haulers. The County does not track C&D debris quantities disposed of at Kekaha MSWLF.

The only company on-island that conducts C&D debris recycling is Pacific Concrete Cutting and Coring, located in Līhu'e. Pacific Concrete currently accepts only concrete and asphalt, but has indicated plans to expand to include other C&D materials. Recycling fees are charged based on typical vehicle size including $295 per tandem trailer for concrete and $395 per semi-trailer for asphalt. The concrete and asphalt are processed through crushing, made into base course or drain rock, and sold to local contractors and residents for $26 per ton.

2.2 City and County of Honolulu (O'ahu)

The City and County of Honolulu (CCH) currently operates a curbside recycling program that provides 160,000 households with blue, green, and gray bins for sorting wastes into mixed recyclables, greenwaste, and trash, respectively. The program, implemented island-wide in 2010, reduced the overall municipal solid waste quantity of landfill waste by 6%, and helped to increase general materials recycling by 21,000 tons (5%) over 2009 rates (DES 2011). During FY2011, 18,000 tons of mixed recyclables and 53,000 tons of greenwaste were collected by the curbside collection system. Mixed recyclables and greenwaste are picked up every other week.

In addition to the residential bin service, CCH owns nine convenience centers and transfer stations, and one MSW landfill. CCH formerly contracted Honolulu Disposal Service, Inc. to provide 100 multi-material recycling bins and process recyclables collected in those bins; however, that contract was closed due to inefficiency in achieving higher recycling rates following implementation of the curbside collection recycling program.

Honolulu Disposal Services Inc., operating under the name Honolulu Recovery Systems, operates a MRF on O'ahu capable of sorting 1,000 tons of MSW per day into separate recyclable and waste streams. Honolulu Recovery Systems then ships recovered cardboard, newspaper, aluminum, plastic, and glass to market. In addition to the Honolulu Recovery Systems MRF, CCH's H-POWER waste-to-energy recovery facility uses magnets to remove ferrous metals prior to incineration and an eddy current separator to extract ferrous and non-ferrous metals from ash after incineration. The CCH owns the H-POWER facility, and contracts the operation to Covanta Energy.

Compared to Kaua'i, Maui, and Hawai'i counties, a large number of private vendors on O'ahu accept recyclable materials (Table 6). This is likely a reflection of the greater waste quantities available, and the associated economies of scale. A breakdown of the number of O'ahu-based companies per material is shown below and is based on the CCH's Department of Environmental Services website. In addition to collection, the website lists an additional 18 vendors that offer pickup of recyclable materials from businesses and residences.

Table 6: Number of Vendors Currently Accepting Recyclables on Oah'u

Material	No. of Vendors		Material	No. of Vendors
Aluminum	8		Motor oil/solvents	8
Appliances/Freon	2		Paper	6
Automotive batteries	3		Plastic bags	4
Rechargeable batteries	7		Plastic beverage containers	4
Cardboard	5		Polystyrene	0
Cooking oil	2		Printer cartridges	3
Glass bottles and jars	3		Tires	1
Metal	8		Yard trimmings	1

Note: Redemption centers, transfer stations, and landfills not included.

Also unique from other Hawaiian islands, which generally collect materials only for eventual recycling elsewhere, several O'ahu-based companies are capable of processing waste products into usable materials:

- Grace Pacific Corporation formerly crushed used glass for use as an aggregate in paving projects ("glassphalt"). However, they stopped this process after the State legislature made optional the former mandate for the counties to use glass in roadway materials (HRS §103D-407).
- Unitek recycles used motor oil into an alternative supplement in diesel fuel. With used tires, the company either shreds them for burning as fuel to generate electricity, or grinds them into crumb rubber for use in landscaping.
- AES Hawaii Generation Plant uses recycled oil and shredded tires as fuel sources at their power plant.
- Pacific Biodiesel recycles used cooking oil into a type of low-sulfur biodiesel fuel.
- Hawaiian Earth Products Ltd. recycles yard trimmings into soil conditioners, compost, and soil blends.
- Island Shell formerly recycled paper into oil change boxes, hydro-mulch, and cellulose insulation until the process became too expensive to maintain. The company used newspaper as feedstock in their operations; however, the material became too expensive as the quantity decreased due to the closure of the *Honolulu Star-Bulletin* and increased internet use.

- Refrigerant Recycling reclaims refrigerant from old appliances and resells the reclaimed product for new systems.

Except the above list, Oʻahu typically has not had the quantities of scale and end market for the recycling of used materials into new materials. Composting has been the most successful venture, as green waste can be composted and sold on Oʻahu. However, in general, excess product and other recyclable waste streams are typically shipped to either Asia or the U.S. mainland for further processing. As discussed above, a number of companies on Oʻahu formerly recycled materials into usable products. These companies indicated the reason for ceasing recycling operations was that the cost and market in Hawaiʻi became prohibitive. At this time, shipping recyclable materials from Kauaʻi to these Oʻahu recyclers does not appear feasible.

2.3 MAUI COUNTY

Maui County consists of the islands of Maui, Molokāʻi, and Lānaʻi. The County of Maui owns and operates two MSW landfills on Maui, one landfill on Lanāʻi, and one landfill on Molokāʻi. As of August 2012, Maui County initiated Phase I of a curbside collection program in the South Maui area that services around 2,000 homes. Three carts were provided to each household for regular MSW, green waste, and mixed recyclables. Maui County is using the information gathered from the curbside collection in the South Maui area to plan for later expansions to service the entire county. Mixed recyclables collected through the curbside collection program are transported to an on-island MRF for separation and processing.

There are currently 17 HI-5 redemption centers within Maui County. Following collection of HI-5 beverage containers, the materials are transported to either of two MRFs on Maui, operated by Aloha Recycling and Maui Disposal. The MRFs bale the HI-5 materials and broker them in out-of-state markets.

Commercial and residential green waste is accepted at the Central Maui Landfill, EKO Compost, Hana Landfill, Maui Earth Compost Company, the Molokai Landfill, and Olowalu Recycling and Refuse Convenience Center. EKO Compost has the current contract to process green wastes collected through the County curbside collection program. Following co-composting with biosolids, the facility sells the compost to contractors and residents on Maui.

The majority of metals recycling on Maui is provided by the Hammerhead Metals Recycling Facility and Maui Tow & Transport. Hammerhead Metals, owned by Schnitzer Steel, has the current contract with Maui County to process large appliances and disposed-of vehicles from residential sources. Hammerhead Metals also buys valuable metals, such as copper and brass, from the general public. Maui Tow & Transport processes scrap metal, mainly from commercial sources. Several other facilities on Maui accept scrap metal for recycling, including the Central Maui Landfill and Maui Tire Recycling LLC. At Molokai Landfill, the County conducts expanded collection events 2–3 times per year for metal materials. Following collection, the materials are shipped to various end recyclers.

Maui Demolition & Construction Landfill is the only operating facility in the county that currently accepts C&D debris for recycling. The facility may cease operations in the near future; however, there are plans for another C&D recovery facility to open on Maui.

Food waste generated at resorts is recycled by Puaʻa Food Waste. The company uses the food waste at pig farms. The pigs are in turn sold to resorts to be used in luau.

2.4 HAWAIʻI COUNTY

Hawaiʻi County owns and operates two landfills, 21 transfer stations, two scrap metal recycling facilities, and two greenwaste recycling facilities. The scrap metal and green waste recycling facilities accept waste from both residential and commercial sources. The scrap metals facilities accept white goods, automobiles and parts, and other types of scrap metal for recycling. Seven recycling and transfer stations are permitted to accept white goods and appliances for recycling and one recycling and transfer station is permitted to also accept source separated scrap metal. Tires are not accepted by any Hawai'i County facility per County code; customers are instead referred to private vendors. There are also privately operated scrap metal and green waste recycling facilities available to the public.

Two-bin recycling containers are provided at recycling and transfer stations, enabling households to dispose of a mix of paper, cardboard, non-HI-5 metal cans, non-HI-5 plastics in one bin, and non-HI-5 glass in another. Businesses are by law not allowed to use these recycling bins. Ten HI-5 certified redemption centers are currently located at designated County recycling and transfer stations. As of 2012, 18 permanent and 2 mobile redemption centers were listed in Hawai'i County.

3.0 WASTE QUANTITIES AND COMPOSITION

Understanding the quantity and types of waste materials to be managed is essential to assessing the feasibility of various waste management programs and technologies that may be included in the RRP from technical, environmental, social, and economic perspectives. This section presents projected waste composition and quantities to be managed over a 20-year planning period. For this FS, the planning period begins in 2017 and extends to 2037. The County has set a target of 70% waste diversion by 2023.

The influence of the roles and responsibilities of various parties for waste management in the County is also discussed, because the actual quantity and composition of material available to the County that can potentially be managed through the RRP may be affected by variations therein.

3.1 POPULATION

Population growth rates were developed from data available from the U.S. Census Bureau and the State of Hawai'i Department of Business, Economic Development and Tourism. The growth rates for the County were estimated at 0.93% for residential and 1.53% for visitor populations on an annual basis. These rates are lower than those projected and used in the ISWMP (1.72% per year residential and 1.62% per year visitor). The population was then projected for future years by multiplying the growth rate by the population from the previous year. The residential and visitor populations were then combined to provide a total population that is reflective of both residential and commercial waste generators. This is consistent with the approach taken in the County's ISWMP, but reflects more recent data. Population projections for 2017–2037 are shown in Table 7. Many of the analyses that follow in this FS rely directly or indirectly on these projections.

Table 7: County Population Levels, 2010 and Projected for 2017–2037

Year	Population		
	Residential	Visitor	Combined
2010	67,217	18,823	86,040
2017	71,717	20,934	92,651
2027	78,673	24,367	103,039
2037	86,303	28,362	114,665

3.2 PER CAPITA WASTE GENERATION RATE

Annual waste quantity data were provided by the County for the years 2008–2010. The per capita waste generation rate (pounds [lbs]/capita/day) was calculated for each year, using the following formula.

$$\text{Generation Rate} = \frac{\text{Quantity of waste (tons/year)}}{\text{Total population}} \times \frac{\text{2,000 (lbs/ton)}}{\text{365 (days/year)}}$$

The ISWMP reported waste generation of 116,389 tons in 2005. County data indicates this increased to approximately 120,000 tons in 2008 and then declined to approximately 105,000 tons in both 2009 and 2010. The estimated per capita waste generation rate for the past 2 years is 6.7 lbs/capita/day. In today's leading economies, it is often observed that the per capita waste generation rate remains relatively constant over time. Changes to product packaging combined with economics and environmental awareness, stewardship, and education can act to offset increases in consumption to stabilize per capita waste generation rates. For this FS, it is assumed that the per capita generation rate will remain constant into future years. This rate is then used along with the population estimates to project total annual waste quantities over the 20-year planning period.

3.3 ANNUAL WASTE GENERATION

The quantity of waste projected to be generated annually over the planning period was calculated based on the population projections and the per capita waste generation rate as described above. The total annual quantity of waste reported in 2010 was divided into residential and commercial streams. The ISWMP indicated that commercial wastes accounted for 56% of the waste generated each year, and the remaining 44% was generated from residential sources. Assuming that the residential and commercial generation rates remain constant over time, the residential and commercial quantities were then escalated throughout the planning period, and summed to estimate total waste generation rates. Projected waste generation by residential and commercial sources is shown in Table 8 for the planning period 2017–2037.

Table 8: Summary of County Municipal Waste Quantities Generated, 2010 and Projected for 2017–2037

Year	Annual Waste Generation (TPY)		
	Residential	Commercial	Total
2010	46,288	58,912	105,200
2017	49,387	65,519	114,905
2027	54,177	76,262	130,439
2037	59,431	88,767	148,199

3.4 WASTE COMPOSITION

The ISWMP provides a breakdown of the waste composition by material as a percentage of the total waste generated. Using these values, the amount of waste generated for each type of material (in TPY) was calculated for the residential and commercial streams. Each waste material was grouped into a category with similar materials. Categories included Recyclables, Organics, Construction & Demolition, Durables, Household Hazardous Waste, Rubber, and Residuals. The expected waste composition during the planning period is shown in Table 9.

Importantly, the waste composition analysis conducted in 2005 and presented in the ISWMP is the composition at the landfill site, which is post or downstream of any diversion activities undertaken by the County or private waste companies. Therefore, the quantities of divertible materials reported as being potentially available for diversion are lower than would be reported if determination of the waste composition was undertaken upstream of the landfill, prior to diversion activities.

The authors of this FS were instructed to use this analysis as the basis of design. In those sections of the report where various diversion activities are discussed, additional quantities are added based on other information provided by the County, when available.

3.4.1 Recyclable Material Quantities

3.4.1.1 RESIDENTIAL RECYCLABLES

As described below, residential recyclables available as MRF feedstock can be obtained from curbside-collected, drop-off, and HI-5 sources.

Table 9: County Municipal Waste Composition Data, 2010 and Projected for 2017–2037

				Tons of Waste Generated											
		Waste Composition %		2010 (based on actual values)			2017 (based on forecast values)			2027 (based on forecast values)			2037 (based on forecast values)		
Material Group	Material	Residential	Commercial	Residential (44% of total)	Commercial (56% of total)	Total	Residential (44% of total)	Commercial (56% of total)	Total	Residential (44% of total)	Commercial (56% of total)	Total	Residential (44% of total)	Commercial (56% of total)	Total
RECYCLABLES															
Paper	Newsprint	5.9%	5.3%	2,731	3,122	5,853	2,914	3,472	6,386	3,196	4,042	7,238	3,506	4,705	8,211
	Magazines	3.0%	2.8%	1,389	1,650	3,038	1,482	1,835	3,316	1,625	2,135	3,761	1,783	2,485	4,268
	High Grade Office Paper	0.8%	2.3%	370	1,355	1,725	395	1,507	1,902	433	1,754	2,187	475	2,042	2,517
	Old Corrugated Cardboard (OCC) and Kraft Bags	5.0%	11.3%	2,314	6,657	8,971	2,469	7,404	9,873	2,709	8,618	11,326	2,972	10,031	13,002
	Mixed Recyclable Paper	7.9%	5.3%	3,657	3,122	6,779	3,902	3,472	7,374	4,280	4,042	8,322	4,695	4,705	9,400
	Non-recyclable Paper	3.5%	3.3%	1,620	1,944	3,564	1,729	2,162	3,891	1,896	2,517	4,413	2,080	2,929	5,009
	Compostable Paper	7.8%	8.2%	3,610	4,831	8,441	3,852	5,373	9,225	4,226	6,253	10,479	4,636	7,279	11,915
	Total	*33.9%*	*38.5%*	*15,692*	*22,681*	*38,373*	*16,742*	*25,225*	*41,967*	*18,366*	*29,361*	*47,727*	*20,147*	*34,175*	*54,323*
Plastics	#1 PET Beverage Containers	0.6%	0.3%	278	177	454	296	197	493	325	229	554	357	266	623
	#1 PET Deposit Beverage Containers	0.4%	0.5%	185	295	480	198	328	525	217	381	598	238	444	682
	#2 HDPE Containers	1.5%	1.3%	694	766	1,460	741	852	1,593	813	991	1,804	891	1,154	2,045
	#2 HDPE Deposit Containers	0.0%	0.0%	—	—	—	—	—	—	—	—	—	—	—	—
	#6 Polystyrene	1.2%	2.3%	555	1,355	1,910	593	1,507	2,100	650	1,754	2,404	713	2,042	2,755
	Other Plastic Containers	0.4%	0.4%	185	236	421	198	262	460	217	305	522	238	355	593
	Other Plastic Products	3.2%	3.9%	1,481	2,298	3,779	1,580	2,555	4,136	1,734	2,974	4,708	1,902	3,462	5,364
	Film/Wrap/Bags	6.0%	6.3%	2,777	3,711	6,489	2,963	4,128	7,091	3,251	4,805	8,055	3,566	5,592	9,158
	Total	*13.3%*	*15.0%*	*6,156*	*8,837*	*14,993*	*6,568*	*9,828*	*16,396*	*7,206*	*11,439*	*18,645*	*7,904*	*13,315*	*21,219*
Metals	Aluminum Non-deposit Beverage Containers	0.0%	0.0%	—	—	—	—	—	—	—	—	—	—	—	—
	Aluminum Deposit Beverage Containers	0.4%	0.4%	185	236	421	198	262	460	217	305	522	238	355	593
	Ferrous Food and Beverage Containers	1.7%	1.4%	787	825	1,612	840	917	1,757	921	1,068	1,989	1,010	1,243	2,253
	Others Ferrous Metals	2.0%	1.6%	926	943	1,868	988	1,048	2,036	1,084	1,220	2,304	1,189	1,420	2,609
	Other Non-ferrous Scrap	1.4%	1.1%	648	648	1,296	691	721	1,412	758	839	1,597	832	976	1,808
	Total	*5.5%*	*4.5%*	*2,546*	*2,651*	*5,197*	*2,716*	*2,948*	*5,665*	*2,980*	*3,432*	*6,412*	*3,269*	*3,995*	*7,263*
Glass	Glass Non-deposit Containers	2.6%	2.0%	1,203	1,178	2,382	1,284	1,310	2,594	1,409	1,525	2,934	1,545	1,775	3,321
	Glass Deposit Containers	1.5%	1.6%	694	943	1,637	741	1,048	1,789	813	1,220	2,033	891	1,420	2,312
	Other Glass/Mixed Cullet	0.6%	0.3%	278	177	454	296	197	493	325	229	554	357	266	623
	Total	*4.7%*	*3.9%*	*2,176*	*2,298*	*4,473*	*2,321*	*2,555*	*4,876*	*2,546*	*2,974*	*5,521*	*2,793*	*3,462*	*6,255*
Total Recyclables		**57.4%**	**61.9%**	**26,569**	**36,467**	**63,036**	**28,348**	**40,556**	**68,904**	**31,097**	**47,206**	**78,304**	**34,114**	**54,947**	**89,060**

				Tons of Waste Generated											
		Waste Composition %		2010 (based on actual values)			2017 (based on forecast values)			2027 (based on forecast values)			2037 (based on forecast values)		
Material Group	**Material**	**Residential**	**Commercial**	**Residential (44% of total)**	**Commercial (56% of total)**	**Total**	**Residential (44% of total)**	**Commercial (56% of total)**	**Total**	**Residential (44% of total)**	**Commercial (56% of total)**	**Total**	**Residential (44% of total)**	**Commercial (56% of total)**	**Total**
OTHER MATERIALS															
Organics	Small Yard Waste	8.0%	5.5%	3,703	3,240	6,943	3,951	3,604	7,554	4,334	4,194	8,529	4,755	4,882	9,637
	Large Yard Waste	0.0%	0.0%	—	—	—	—	—	—	—	—	—	—	—	—
	Total Yard Waste	*8.0%*	*5.5%*	*3,703*	*3,240*	*6,943*	*3,951*	*3,604*	*7,554*	*4,334*	*4,194*	*8,529*	*4,755*	*4,882*	*9,637*
	Food Waste	15.7%	13.5%	7,267	7,953	15,220	7,754	8,845	16,599	8,506	10,295	18,801	9,331	11,984	21,314
	Other Organic	0.8%	0.7%	370	412	783	395	459	854	433	534	967	475	621	1,097
	Total	*24.5%*	*19.7%*	*11,341*	*11,606*	*22,946*	*12,100*	*12,907*	*25,007*	*13,273*	*15,024*	*28,297*	*14,561*	*17,487*	*32,048*
C&D	Non-treated Wood	0.3%	3.4%	139	2,003	2,142	148	2,228	2,376	163	2,593	2,755	178	3,018	3,196
	Treated Wood	1.7%	1.3%	787	766	1,553	840	852	1,691	921	991	1,912	1,010	1,154	2,164
	Total	*2.0%*	*4.7%*	926	2,769	3,695	988	3,079	4,067	1,084	3,584	4,668	1,189	4,172	5,361
	Construction/ Demolition/ Renovation Debris	1.5%	1.1%	694	648	1,342	741	721	1,462	813	839	1,652	891	976	1,868
	Total	*3.5%*	*5.8%*	*1,620*	*3,417*	*5,037*	*1,729*	*3,800*	*5,529*	*1,896*	*4,423*	*6,319*	*2,080*	*5,148*	*7,229*
Durables (Electronics)	Electrical and Household Appliances	1.8%	0.7%	833	412	1,246	889	459	1,348	975	534	1,509	1,070	621	1,691
	Central Processing Units/ Peripherals	0.0%	0.1%	—	59	59	—	66	66	—	76	76	—	89	89
	Computer Monitors/ TVs	0.0%	0.0%	—	—	—	—	—	—	—	—	—	—	—	—
	Cell Phones and Charges	0.0%	0.0%	—	—	—	—	—	—	—	—	—	—	—	—
	Other Durables	0.3%	0.4%	139	236	375	148	262	410	163	305	468	178	355	533
	Total	*2.1%*	*1.2%*	*972*	*707*	*1,679*	*1,037*	*786*	*1,823*	*1,138*	*915*	*2,053*	*1,248*	*1,065*	*2,313*
HHW	Automotive Products	0.0%	0.0%	—	—	—	—	—	—	—	—	—	—	—	—
	Paints and Solvent	0.0%	0.0%	—	—	—	—	—	—	—	—	—	—	—	—
	Pesticides, Herbicides, Fungicides	0.0%	0.0%	—	—	—	—	—	—	—	—	—	—	—	—
	Household Cleaners	0.0%	0.0%	—	—	—	—	—	—	—	—	—	—	—	—
	Lead-Acid Batteries	0.0%	0.0%	—	—	—	—	—	—	—	—	—	—	—	—
	Other Batteries	0.5%	0.4%	231	236	467	247	262	509	271	305	576	297	355	652
	Other HHW	0.2%	0.0%	93	—	93	99	—	99	108	—	108	119	—	119
	Mercury-containing Products	0.0%	0.0%	—	—	—	—	—	—	—	—	—	—	—	—
	Sharps	0.1%	0.1%	46	59	105	49	66	115	54	76	130	59	89	148
	Total HHW	*0.8%*	*0.5%*	*370*	*295*	*665*	*395*	*328*	*723*	*433*	*381*	*815*	*475*	*444*	*919*
Rubber		0.2%	0.3%	93	177	269	99	197	295	108	229	337	119	266	385
Residuals (non-divertible)	Textiles and Leathers	3.2%	4.6%	1,481	2,710	4,191	1,580	3,014	4,594	1,734	3,508	5,242	1,902	4,083	5,985
	Diapers	2.9%	1.7%	1,342	1,002	2,344	1,432	1,114	2,546	1,571	1,296	2,868	1,724	1,509	3,233
	Other Inorganic	1.8%	1.5%	833	884	1,717	889	983	1,872	975	1,144	2,119	1,070	1,332	2,401
	Fines/ Super Mix	3.6%	2.5%	1,666	1,473	3,139	1,778	1,638	3,416	1,950	1,907	3,857	2,140	2,219	4,359
	Other	0.3%	0.3%	139	177	316	148	197	345	163	229	391	178	266	445
	Total	*11.8%*	*10.6%*	*5,462*	*6,245*	*11,707*	*5,828*	*6,945*	*12,773*	*6,393*	*8,084*	*14,477*	*7,013*	*9,409*	*16,422*
Total Other Materials		**42.9%**	**38.1%**	**19,858**	**22,445**	**42,303**	**21,187**	**24,963**	**46,149**	**23,242**	**29,056**	**52,298**	**25,496**	**33,820**	**59,316**
GRAND TOTAL (RECYCLABLES + OTHER) [a]		**100%**	**100%**	**46,427**	**58,912**	**105,339**	**49,535**	**65,519**	**115,053**	**54,339**	**76,262**	**130,601**	**59,610**	**88,767**	**148,377**

Note: Composition data are calculated from Total Residential and Commercial Tons of Waste Generated reported in Table 8.
[a] Grand Total values may vary slightly from the "Generational Quantity" values due to rounding in the residential and commercial waste composition %.

3.4.1.1.1 Curbside-collected Recyclables

As described in Section 2.1.2, the County initiated a pilot curbside recycling program in September 2011. Under the program, recyclables were collected from 1,300 households, using a single-stream system wherein a household placed all of their recyclable materials in one provided container. The pilot program was initially conceived as a 6-month project and was eventually extended for a 12-month period. The goal of the program was to test the curbside recycling service to determine potential participation rates and other logistics associated with island-wide implementation of a recycling program.

The materials collected included:

- Cardboard
- Newspaper
- Mixed paper
- Glass food and beverage containers (HI-5 and non-HI-5)
- Aluminum beverage containers (HI-5)
- Plastic containers #1 & #2 (HI-5 and non-HI-5)

On average, households participating in the pilot placed 342 pounds of recyclables out for collection per year. Multiplying this annual rate by 18,500 households (SAIC 2011) yields an annual estimate of 3,160 TPY, if the pilot project was implemented island-wide.

The report on the pilot project's results (SAIC 2011) noted, based on a review of other U.S. recycling programs, that 400 pounds per household per year are typical of recovery rates after 1 year of operation, and 520 pounds per household per year for a fully mature program. Recommendations included in the report included:

- Develop a MRF or support the development of such a facility in the private sector capable of processing a mixed, single stream of recyclable materials.
- Implement single-stream curbside collection of recyclables island-wide.
- After the island-wide curbside collection program is in place, adjust the Kaua'i Recycles drop-bin contract accordingly. Reduce frequency of service, collect a mixed stream of recyclables, and reduce the number of drop-bins. Continue to accept all materials collected in the pilot program, and expand the list of materials to include steel cans. Investigate the feasibility of including #3 through #7 plastics.
- Implement "Pay as You Throw" (PAYT) (in which residents are charged for curbside collection of waste based on the amount disposed of, rather than as a fixed fee not tied to disposal quantity) in conjunction with the island-wide curbside collection program to provide an economic incentive for public participation. The PAYT charge would provide incentive for households to maximize the amount of waste diverted from disposal and encourage participation in the curbside recycling program and the County's other recycling and diversion efforts.

Using per-household generation rates between 400 and 520 pounds per household per year, and given 18,500 households on the island, curbside collection of recyclables could generate 3,700–4,800 TPY. Furthermore, if the housing stock that will be served by a curbside recycling program were projected to grow at an annual rate of 0.93% per year over the planning period, the tonnage of curbside-collected recyclable materials would increase as shown in Table 10. In order to achieve a diversion goal of 70% by 2023, consistent with the County's zero-waste policy, the County believes that greater recovery of household recyclables is necessary. In conjunction with aggressive supporting policies including PAYT, County staff suggest a range of 450–650 lbs/household/year of recyclables captured. The tonnage of curbside-collected recyclables under this scenario is also shown in Table 10.

Table 10: Projected Increase in Tonnage of Curbside-collected Recyclable Materials, 2017–2037

Year	Projected Number of Households	Typical Recovery Estimates		County Recovery Estimates	
		TPY @ 400 lbs/hh/year	TPY @ 520 lbs/hh/year	TPY @ 450 lbs/hh/year	TPY @ 650 lbs/hh/year
2017	19,557	3,911	5,085	4,400	6,356
2027	21,453	4,291	5,578	4,827	6,972
2037	23,534	4,707	6,119	5,295	7,649

hh household

3.4.1.1.2 Drop-off Recyclables

Table 11 lists the County-reported quantities of recyclable materials received at the County's various recyclable drop-off locations from 2007 to 2011.

Table 11: Recyclables Received at the County's Drop-off Depots, 2007–2011

Year	Recyclables Received at the County's Drop-off Depots (Tons)
July 1, 2007 – June 30, 2008	2,403
July 1, 2008 – June 30, 2009	2,858
July 1, 2009 – June 30, 2010	1,568
July 1, 2010 – June 30, 2011	1,608
Average between 2007 and 2011	2,109

When the County implements the recyclables curbside collection program, it is expected that a significant portion of the current drop-off tons would be recovered through the curbside program. For planning purposes, it is simply assumed that this material will continue to be captured in its entirety.

3.4.1.1.3 HI-5 Recyclables

In addition to the recyclable materials dropped off at the drop-off depots noted above, Table 12 shows the number of materials redeemed by container type for Kaua'i in FY2011 via the State's Deposit Beverage Container (HI-5) Program.

Table 12: HI-5 Container Quantities and Estimated Tonnage Recycled in Kaua'i for FY2011, by Material Type

Parameter	Aluminum	Bi-metal	Glass	Plastic	Total
Total Containers	21,429,026	83,672	10,028,762	13,462,158	45,003,619
Estimated Tonnage [a]	335	7.1	2,090	300	2,730

[a] Based on current DOH weight rates.

Currently the certified redemption centers on Kaua'i do not market their HI-5 materials. Instead, GID receives these materials from the CRCs, and bales or containerizes them for shipment directly to Asia or U.S. mainland markets.

If the County were to proceed with the development of their own MRF, it is not known to what extent the current redemption operators would use the County's MRF to process and market their HI-5 materials, or if they would continue to use the GID facility. For the purposes of sizing the RRP facility, it is assumed that 30% of the current quantity (i.e., 819 TPY) may be processed at the County's MRF initially, with the potential to increase to 70% by the end of the planning period.

3.4.1.1.4 Total Potential Residential Recyclables

Based on the foregoing, Table 13 summarizes the potential annual quantity of residential recyclables that may be collected and require processing by the end of the 20-year planning period (i.e., 2037).

Table 13: Summary of Potential Residential Recyclables, Tons of Materials, 2037

	Potential Residential Recyclables (TPY by 2037)	
Recyclable Source Material	**Low Estimate**	**High Estimate**
Curbside Recycling Program (County estimates)	5,295	7,649
Current Drop-off Recyclables (which may be captured by curbside in the future)	1,568	2,858
HI-5 Materials [a]	819	1,911
Total Residential Recyclables	7,682	12,418

Sources: Curbside Recycling: Table 10; Drop-off Recyclables: Table 11; HI-5 Materials: Table 12

[a] Assumes 30% of currently collected HI-5 materials may be processed at the MRF, increasing to 70% by end of planning period.

3.4.1.2 Commercial Recyclables

In addition to the residential recyclable quantities noted above, the proposed MRF will have the capacity to process commercial recyclables as well. The estimated quantity of commercial wastes generated annually over the planning period were developed in Section 3.3 and summarized in Table 8. This information is repeated in Table 14, as it forms the basis for the remainder of this section. The potential quantity of recyclables from the commercial sector is shown in Table 15.

Table 14: Summary of Total Waste Generated in County, 2010 and Projected for 2017–2037

	Annual Waste Generation (TPY)		
Year	**Residential (44% of total)**	**Commercial (56% of total) [a]**	**Total**
2010	46,288	58,912	105,200
2017	49,387	65,519	114,905
2027	54,177	76,262	130,439
2037	59,431	88,767	148,199

Note: Totals from Table 8.

[a] Sample calculation: (105,200 total tons of waste per year) × (56% commercial) = 58,912 tons of commercial waste per year

Table 15: Commercial Recyclables Composition and Generation by Material Type in County, 2010 and Projected for 2017–2037

Parameter	Material Type (TPY)				Commercial Recyclables Available (TPY)
	Total Recyclable Fibers [a]	#1 & #2 Plastics	Total Food & Beverage Ferrous & Non-ferrous Metal Containers	Total Food and Beverage Glass Containers	
Composition (%)	27.0%	2.1%	1.8%	3.6%	34.5%
2010	15,906	1,237	1,060	2,121	20,325
2017	17,690	1,376	1,179	2,359	22,604
2027	20,591	1,602	1,373	2,745	26,310
2037	23,967	1,864	1,598	3,196	30,625

[a] Sample calculation: 58,912 tons of commercial waste (from Table 14) × (27% fibers) = 15,906 TPY of total recyclable fibers from commercial sources

County staff estimate that currently 15% of the commercial waste stream is being diverted from disposal. Data are not available to quantify this estimate, and the waste composition data represent only landfilled waste. Based on the quantity of commercial waste generated in 2010 (Table 14), it is estimated that approximately 9,000 tons of commercial recyclables are currently being diverted.

The numbers presented in Table 15 present an upper limit on diversion: it will not be possible to divert 100% of the material stream from the landfill. In addition, some of the diverted materials may be managed by the private sector. With the implementation of policies and incentives directed at the commercial waste stream, the County has a goal of achieving a 60% diversion rate. The County has also estimated the percentage of the commercial recyclables it may capture and manage in the future through the RRP. County staff believe that the County will manage from 40% to 60% of the diverted commercial recyclables by the end of the planning period. It is estimated that recyclables from the commercial sector will contribute between 9,300 and 14,000 additional TPY to the MRF (Table 16) by the end of the planning period.

Table 16: Tons of Commercial Recyclables Recoverable by County Over the Planning Period

Year	Commercial Recyclables Available (TPY)	Forecast Diversion%	Estimated Amount Diverted (TPY)	Estimated % Managed by County	Estimated Quantity Managed by County (TPY)
2010	20,325 + 9,000	—	9,000	0	0
2017	22,604 + 9,000	30%	9,481	15	1,422
2027	26,310 + 9,000	45%	15,890	40	6,356
2037	30,625 + 9,000	60%	23,775	60	14,265

Note: Commercial Recyclables Available from Table 15.

These assumptions regarding capture of recyclables from the commercial sector are aggressive (40–60% of diverted material over the planning period), since the County does not have flow control over the commercial waste stream; therefore, there is no guarantee that the commercial waste haulers will use the County's MRF. However, given the County's 70% diversion goal, an aggressive approach is required. Commercial parties may employ other waste management strategies (e.g., they may market high-grade materials and only direct lower-grade materials to the County's facility). While the County will pursue policies and programs to entice the commercial sector to fully utilize the County's MRF, the County could needlessly expose itself to financial risk if it over-sized the MRF based on overly optimistic waste stream projections. It is noted that business risks may also exist for the private contractors and their ability to provide ongoing cost effective diversion services. As a result, the County may need to offer these services in order to achieve their waste diversion goals.

3.4.2 Organic Material Quantities

Three primary sources of organics will be available for composting: greenwaste from residential and commercial sectors, biosolids, and food waste. The current and projected quantities of each of these materials that may be available for processing at the proposed facility are summarized below.

3.4.2.1 GREENWASTE QUANTITIES

Greenwaste includes lawn and tree trimmings, shrubbery, and Christmas trees. Section 2.1.4 summarizes the County's current greenwaste processing system, which includes collection at the landfill and transfer stations and contracts with three private processing companies. Table 17 summarizes the quantities of greenwaste received at the County's landfill and transfer stations in recent years.

Table 17: County Greenwaste Diversion in 2005 and 2007–2010

	Greenwaste Received (Tons)		
Year(s)	County Transfer Stations	Kekaha MSWLF	Total
2005	—	—	10,585
July 2007–June 2008	10,814	1,221	12,035
July 2008–June 2009	10,408	1,374	11,782
July 2009–June 2010	17,809	930	18,739

Source: County of Kaua'i, Hawai'i
— For 2005, only the total amount was recorded.

For the purposes of this FS, it is assumed that all of the material currently dropped off at the transfer stations and the landfill site would be available for processing at the centralized composting facility located at the RRP. This assumption provides flexibility in the event of any potential future changes to existing operations and does not impact current operations. For planning purposes, the current level of greenwaste capture and diversion (i.e., 18,739 TPY) is assumed to remain constant for the planning period.

Based on the waste composition analysis, in addition to the material being diverted via the transfer stations and the landfill, additional organic matter from both the residential and the commercial sectors is not being recovered, and is presumably disposed of at the landfill. The quantities disposed of in 2010 (from Table 8) and projections of these quantities throughout the planning period are presented in Table 18.

Table 18: Quantities of Greenwaste Disposed of at the County's Municipal Solid Waste Landfill, 2010 and Projected for 2017–2037

	Greenwaste Disposed of at Landfill (TPY)		
Year	Residential	Commercial	Total
2010	3,703	3,240	6,943
2017	3,951	3,604	7,554
2027	4,334	4,194	8,529
2037	4,755	4,882	9,637

Source: Table 9: Yard Waste data

Upon full implementation of a curbside collection program, as proposed in the ISWMP, and further enforcement of bans on the disposal of organics in the landfill from the commercial sector, a portion of the greenwaste forecast to be disposed of at the landfill can be diverted and processed at the RRP. The capture rate from the residential sector is assumed to increase from 30% to 60% over the planning period. It is also assumed that the current commercial composting operators on the island will continue to provide their service to their commercial clients; therefore, a lower recovery rate from the commercial sector has been assumed. The assumed capture rates from the commercial sector over the planning period are 20%, 30%, and 40% for the years 2017, 2027, and 2037, respectively. Table 19 summarizes the projected quantities of greenwaste.

Table 19: Quantities of Greenwaste Recoverable from Disposal after Introduction of County Curbside Collection, 2010 and Projected for 2017–2037

	Greenwaste Disposed of by Year (TPY)		Assumed Recovery (%)		Greenwaste Recoverable (TPY)		
Year	Residential	Commercial	Residential	Commercial	Residential	Commercial	Projected Total Additional Recovery
2010	3,703	3,240	—	—	—	—	—
2017	3,951	3,604	30%	20%	1,185	721	1,906
2027	4,334	4,194	60%	30%	2,600	1,258	3,859
2037	4,755	4,882	60%	40%	2,853	1,953	4,806

Note: Greenwaste Disposed of by Year data from Table 18.
— not implemented

Adding the greenwaste from the transfer stations (18,740 TPY; Table 17) to the greenwaste expected to be diverted from the landfill (Table 19) gives the estimated total amount of greenwaste available for processing at the RRP, as summarized in Table 20.

Table 20: Projected Quantities of Greenwaste Available for Processing at the RRP

Year	Greenwaste Quantity (TPY)
2017	20,645
2027	22,598
2037	23,545

Note: Quantities summed from:
Table 17: July 2009–June 2010 Total +
Table 19: Projected Total Additional Recovery

3.4.2.2 BIOSOLID QUANTITIES

Biosolids include the residual solids and semi-solids separated during the treatment of wastewater at the County wastewater treatment plant. The RRP composting facility can also process the County's biosolids (sewage sludge), which would result in diversion from the landfill and the addition of relatively small amounts of nutrients to the composted product. While no data are available regarding the composition or quality of the biosolids, based on the lack of identified industrial pollution sources served by Kaua'i's wastewater treatment plants, it is assumed that the biosolids are suitable for the anticipated end-use as compost. In 2005, the County disposed of 1,380 tons of biosolids from a contributing population of 86,000 people, which equates to 32.2 lbs/capita/year. Using the population forecast presented in Section 3.1 while holding the per capita bio-solids generation rate constant, the potential quantity of biosolids that may be available for processing at RRP are estimated in Table 21.

Table 21: Biosolid Quantities Available for Processing by the County in 2005, 2010, and Projected for 2017–2037

Year	Population	Per Capita Generation Rate (lbs/capita/year)	Total Biosolids (TPY)
2005	86,000	32.2	1,385
2010	86,040	32.2	1,385
2017	92,651	32.2	1,492
2027	103,039	32.2	1,659
2037	114,665	32.2	1,846

Source: *Centralized Composting Facility Master Plan* (Beck 2008); population data from Table 7.

3.4.2.3 Food Waste Quantities

Commercial food waste includes clean, unprepared food material typically generated in the preparation for market or the preparation of meals for consumption and the remaining uneaten food and scraps. Commercial food waste sources include grocery stores, hotels, restaurants and convenience stores. Residential food waste is generated in the preparation of meals plus any food not consumed during meals and discarded. In 2010, approximately 15,200 tons of residential and commercial food waste was disposed of at Kekaha MSWLF, and 670 tons of food waste was reused by pig farmers in the County. Therefore, a total of approximately 15,870 tons of food waste was generated by residential and commercial sources, i.e., approximately 1.0 lb/capita/day, as calculated below:

$$\frac{15{,}870 \text{ tons} \times 2{,}000 \text{ lbs per ton}}{86{,}000 \text{ total population} \times 365 \text{ days/year}} = 1.0 \text{ lb/capita/day}$$

The 2005 Kaua'i waste characterization study indicated that approximately 7,257 tons of food waste from residents was disposed of, and that no measurable amount was recycled. This is equivalent to approximately:

$$\frac{7{,}257 \text{ tons} \times 2{,}000 \text{ lbs/ton}}{67{,}217 \text{ residential population} \times 365 \text{ days/year}} = 0.59 \text{ lb/capita/day}$$

Therefore, if the total per capita organics generation rate is 1.0 lb/capita/day and the residential organics generation rate is 0.59 lb/capita/day, then the commercial food waste generation rate is 0.41 lb/capita/day.

As outlined in the ISWMP, the County intends to focus initially on the diversion of commercially generated food waste. Table 22 summarizes the forecast food waste quantities from all commercial sources based on the total County population.

Table 22: Suitable Commercial Food Waste Available for Processing/Recovery by the County, 2010 and Projected for 2017–2037

Year	Total County Population	Commercial/Capita Organics Generation Rate (lb/capita/day)	Commercial Organics Generated (TPY) [a]	% Assumed Suitable/ Acceptable for Processing at the RRP (%)	Assumed Capture Rate(%)	Total Commercial Food Waste (TPY) [b]
2010	86,040	0.41	6,438	50%	25%	805
2017	92,651	0.41	6,933	60%	30%	1,248
2027	103,039	0.41	7,710	70%	40%	2,159
2037	114,665	0.41	8,580	75%	50%	3,217

Note: Population data from Table 7.
Example calculations:
[a] (86,040 capita) × (0.41 lb/capita/day) × (365 days/2,000 lbs/ton) = 6,438 (tons)
[b] (6,438 tons) × 50% × 25% = 805 (tons)

The County has also indicated that in the long term, in order to further maximize waste diversion, they will initiate collection and processing of residential food waste. It is projected that this program would be implemented by approximately 2020 or later. Table 23 summarizes the forecast residential food waste quantities.

Table 23: Residential Food Waste Quantities Available for Processing/Recovery by the County, 2010 and Projected for 2020–2037

Year	County Residential Population	Residential Per-Capita Organics Generation Rate (lb/capita/day)	Residential Organics Generated (TPY) [a]	% Assumed Suitable/ Acceptable for Processing at the RRP (%)	Assumed Capture Rate(%)	Total Residential Food Waste (TPY) [b]
2010	67,217	0.59	7,238	80%	0%	0
2020	73,804	0.59	7,947	80%	50%	3,179
2027	78,673	0.59	8,471	80%	60%	4,066
2037	86,303	0.59	9,293	80%	70%	5,204

Note: Population data from Table 7.
Example calculations:
[a] (73,804 capita) × (0.59 lb/capita/day) × (365 days/2,000 lbs/ton) = 6,438 (tons)
[b] (7.947 tons) × 80% × 50% = 3,179 (tons)

3.4.2.4 SUMMARY OF PROJECTED ORGANIC MATERIAL QUANTITIES

Table 24 summarizes the total amount of suitable organic material that may be available for processing at the RRP over the planning period.

Table 24: Summary of Organics Available from All County Sources, 2010 and Projected for 2017–2037

	TPY					
Year	Greenwaste from Transfer Stations and Landfill [a]	Greenwaste Recovered from Curbside Collection [b]	Biosolids [c]	Suitable Commercial Food Waste [d]	Suitable Residential Food Waste [e]	Total Available Organics
2010	18,739	—	1,385	805	—	20,929
2017	18,739	1,906	1,492	1,248	—	23,385
2027	18,739	3,859	1,659	2,159	4,066	30,482
2037	18,739	4,806	1,846	3,217	5,204	33,812

— not implemented

[a] From Table 17: July 2009–June 2010 total
[b] From Table 19: Projected Total Additional Recovery
[c] From Table 21: Total Biosolids
[d] From Table 22: Suitable Commercial Food Waste
[e] From Table 23 Residential Food Waste Quantities Available for Processing/Recovery by the County

3.5 HIERARCHY OF DIVERSION INITIATIVES

A range of material types and quantities will be available for the RRP. Some of the programs and technologies available at the RRP may overlap and compete for the same materials. Therefore, greater emphasis or preference may be given to some materials or processes which provide the County more benefit, less cost, or a favorable ratio of cost to benefit. Specific examples of this include:

- Recyclables – resources with beneficial alternative use, account for a large portion (including paper, plastics, metals, and glass) of divertible wastes, and have a high revenue potential.
- Green and food waste – resources with beneficial alternative use, elimination from landfill helps reduce production of landfill gas (i.e., methane) and greenhouse gas emissions and improves leachate quality.
- HHW and electronics – elimination from the landfill improves leachate quality and minimizes risks to groundwater.
- Construction and demolition debris – large quantities of inert material can be beneficially reused locally.

3.6 WASTE MANAGEMENT ROLES AND RESPONSIBILITIES

The County is responsible for the curbside collection of MSW from all single-family residences in the County. The residents pay for the service via their property tax bill. Curbside collection is limited to 96 gallons, although additional collection service can be obtained for an extra fee, and the County does not collect bulky items (e.g., sofas, chairs, tires, white goods) as part of its curbside collection service. The County also provides waste collection services to a small number of commercial establishments. These commercial customers are charged a collection fee based on the volume of waste collected weekly.

The majority of commercial businesses in the County contracts directly with private waste haulers. Some businesses haul their own wastes directly to a transfer station or the landfill.

As described in Sections 3.3 and 3.4, approximately 56% of the waste generated on Kauaʻi is from the commercial sector and is not managed by the County. Virtually all of this waste material is managed by the private sector, outside the control of the County. This is an important factor to consider in the development of the RRP and in trying to understand what volume and composition of waste will realistically be attracted by the County to the RRP and how will this affect the feasibility of the various components.

4.0 POTENTIAL RRP COMPONENTS AND TECHNOLOGIES

A RRP can include a wide range of components and technologies for diverting those recoverable materials accepted directly from public and private contractors or waste generators. The decision to implement particular components and technologies as part of the RRP is a function of a number of factors, including end use or market availability for the recovered material and cost considerations. The County has also made a commitment as part of its Zero Waste Resolution to divert as much as 70% of the waste materials generated from the municipal landfill. The RRP can be designed to accommodate any or all potential diversion components and technologies, which can be implemented in a staged approach when favorable conditions are met.

This section introduces the integrated public drop-off and reuse facility concept in Section 4.1, identifying essential waste management components that are typically recommended for any RRP. The majority of these essential components are then described and assessed individually in Sections 4.2–4.10.

Other potential components and technologies that could be co-located at the RRP to optimize operations and provide potential synergies are described and assessed in Sections 4.11–4.17). Some of these other components mutually exclude each other. For example, to manage the organics, the County would likely choose one of the following options:

- Composting facility (Section 4.12)
- Anaerobic digestion of biomass (Section 4.13)
- Bio-refinery facility (Section 4.14)

Similarly, if it is decided to invest in waste conversion, the County could choose one of the following:

- Waste to energy facility (Section 4.16)
- Waste to fuel facility (Section 4.17)

4.1 INTEGRATED PUBLIC DROP-OFF AND REUSE FACILITY

4.1.1 Description

Typically, there are a set of components and technologies that are generally included as part of a RRP development. These items are identified first to allow a proper analysis and assessment of potential complementary processing technologies that could be selected and integrated into the RRP. The County has identified a comprehensive range of potential components and technologies, many of which are already provided in some form on-island. Including these as part of the RRP may offer the opportunity to support and complement the programs already available to residents, or in some cases may provide for a more economical alternative to those existing facilities. Some of the County's existing diversion facilities may or may not be available for use in the future.

Integrating or centralizing drop-off and reuse components at a single location can enhance the experience of a RRP user, decrease the transportation and time that may otherwise be required to take materials to multiple locations, and promote increased diversion. Public access to the RRP is typically restricted to the drop-off and reuse components. Consequently, it is important to maximize user friendliness, efficiency, promotion and education, and safety.

The layout of the public drop-off should support the potential for maximizing waste diversion or resource recovery. Typically a resident would first encounter those programs or services supporting the concept of waste reduction and reuse. The facilities supporting these programs will need to provide adequate parking and unloading areas. RRP users would then encounter the drop-off area for those materials that can be diverted from the landfill through other processes, including recyclables, greenwaste, HHW, electronics, scrap metal, C&D material, used tires, hard-to-recycle materials, waste motor oils and filters, and cooking oil. This area can be flexible and be adapted to changing market conditions for materials and changing generation rates. Consistent with current County practices, residents would not pay to use these programs or services, while a fee may apply to small-quantity commercial generators.

Finally, an outlet for non-recyclable or residual materials would be provided. While it is not current County policy, waste diversion may be further supported in the future by requiring payment of a weight-based or flat fee for residual waste drop-off.

Combined Facility Characteristics: Figure 1 displays a conceptual schematic of an integrated public drop-off and reuse facility.

Figure 1: Typical Integrated Public Drop-off and Reuse Area

The combined area required for all of the drop-off components is a function of the site area available, anticipated number of vehicles to be accommodated during peak periods, parking requirements, and access for service vehicles.

The proposed integrated or central public drop-off facility includes the following:

- Up to four bins (two active and two on standby) for the receipt/temporary storage of single-stream or commingled recyclable materials, plus one bin for oversized cardboard and six to eight bins for residential waste drop-off (see Section 4.2)
- A HI-5 redemption center (see Section 4.2.1)
- A specially designed building for the receipt, consolidation, lab-packing, and storage of HHW (see Section 4.3) and consolidation of electronic waste (see Section 4.4)

- One duty bin and a standby bin for each of the following, plus associated processing areas:
  - Greenwaste
  - Scrap metals including white goods and propane tanks (see Section 4.5)
  - Construction and demolition waste (see Section 4.6)
  - Used tires (see Section 4.7)
- An enclosed storage area for hard-to-recycle materials (see Section 4.8) not already addressed through the other proposed facilities and programs
- A reuse center (Section 4.9) and an educational center (Section 4.10)
- Drop-off covered areas for waste motor oil and filters and for used cooking oil (space to accommodate four to six 55-gallon drums)

4.1.2 Space Requirements

Based on similar facilities developed by AECOM on the mainland, approximately 5–10 acres may be required. The detailed layout, acreage, and costs will be refined upon completion of this FS, during the conceptual design phase.

4.1.3 Benefit (Effective Diversion)

As outlined above, the County reports that more than 32,000 tons of material were diverted from disposal in 2010. This is equivalent to a diversion rate of approximately 31%. This has been achieved through a network of drop-off type facilities across the island. With the implementation of curbside collection for residential recyclables and greenwaste, the reliance on drop-off facilities for those materials is expected to decrease. Currently the County collects approximately 2,700 TPY of recyclables through their current network of drop-off depots. This represents approximately 2% of the total waste stream, or about 5% of the residential wastes. If the RRP recyclables drop-off replaced only the KRC, it is estimated that approximately 250 tons of recyclables would be received annually. The recyclables received from small, direct-haul commercial generators are expected to increase based on County policies and incentives. It is estimated that these generators may generate a further 250 tons of recyclables annually. Based on these assumptions, it is estimated that the amount of recyclables collected at the RRP drop-off would be approximately 500 TPY.

Approximately 18,700 TPY of greenwaste are currently received and managed by the County. The majority of this material is reportedly generated by residential sources. If a residential curbside collection program is implemented for greenwaste, this portion of the greenwaste would be taken directly to the processing area at the RRP. Similar to the recyclables, it is difficult to predict what portion of the greenwaste may be dropped off at the existing transfer stations or the RRP after implementation of the RRP.

The capture of those materials not managed through a curbside program (e.g., HHW, tires, scrap metal, electronics) should continue to be recovered at current or increased rates (based on increased access for residents to these programs) through a public drop-off at the RRP. Based on current County diversion data, these materials account for approximately 10,600 TPY of diverted waste. Material generated by commercial sources in larger quantities (e.g., scrap metal accounted for 1,900 tons and derelict automobiles an additional 1,800 tons in 2011) would not be received at the drop-off area; instead, they would be taken directly to the processing area at the RRP. Assuming the remaining 6,900 TPY of other currently diverted material is received at the drop-off and reuse center, this is equal to approximately 5% diversion. Based on AECOM's experience with similar facilities, mature depot recycling programs with a reasonable level of public participation achieve approximately 7–12% diversion of the residential waste stream. This suggests that by the end of the 20-year planning period, an additional 9,900 TPY may potentially be diverted through the drop-off and reuse center. This estimated quantity would be less if the existing network of transfer stations and depots remain open and are used to the extent that they are currently.

4.1.4 Capital Cost Requirements

Depending on the specific design features, capital costs for the integrated drop-off and reuse center, including site grading and paving, structures, mobile equipment and bins are estimated at approximately $8.9 million.

Table 25: Estimated Capital Costs for Public Drop-off and Reuse Facility

Capital Cost Item	Cost Breakdown	Cost ($, rounded)
Site Clearing & Grubbing	Lump sum for 13.5 acres	$150,000
Excavation	Lump sum	$450,000
Paved Roadways	2,300 linear feet	$252,000
Other Paved Areas	45,450 ft^2	$227,250
Scale & Scale House	Lump sum	$200,000
Residual Drop-off Area Canopy	6,000 ft^2	$450,000
HHW & Electronics Building	5,000 ft^2	$1,250,000
HI-5 Building	3,000 ft^2	$750,000
Reuse Centre	11,000 ft^2	$2,750,000
Utilities	Lump sum	$500,000
Permits & Engineering	10%	$648,000
Contingency	20%	$1,296,000
Total		**$8,923,250**

4.1.5 Operations and Maintenance (O&M) Cost Requirements

Operating costs for all of the County's current drop-off and recycling programs are projected in the ISWMP to be approximately $1.4 million annually.

4.1.6 Comments

The public drop-off and reuse facility is recommended as a key part of the overall RRP as a cost-effective way to consolidate and promote diversion from the landfill. The center provides a common level of service available to all residents. These components are well understood as most are currently being utilized by the County. A wide variety of materials can be managed in one location, thus providing additional efficiencies and cost savings for operations equipment and staff requirements. These types of facilities are easy to manage and cost-effective to staff. In addition, the highly visible nature of the various onsite activities helps to increase environmental awareness and further educate the public on the opportunities to maximize diversion.

By co-locating the components at the RRP, it is anticipated that efficiencies can be gained. The capital and operating costs outlined above are indicative for this type of program and for planning purposes. More definitive costs can be developed when the County's specific design requirements for this aspect of the RRP have been identified.

Case Study – Drop-off Facilities in Peel Region, Ontario. The Peel Region Municipality in Ontario, Canada, with a population of 1.3 million, has five public drop-off and reuse facilities for residential waste, or one facility for every 260,000 people. Details regarding the size, quantities of waste received, and costs are as follows:

- **Size:** The facilities are approximately 5 acres, adjusted as needed based on the property available.
- **Services:** The demand for services and any additional facilities is evaluated after the facility begins operation. Residential customer onsite surveys are conducted to assist with

determining from what area the site's visitors are travelling and what materials are being delivered. The facilities each receive 3,000–13,000 TPY of waste.

- **Cost:** The net operating costs of the busier facilities are approximately $250,000–$300,000 per year. This is equivalent to approximately $23 per ton. General maintenance is budgeted for during annual budget season and varies from site to site, based on factors such as the age of the facility and annual assessments of anticipated work to be required. Capital costs were $6–$8 million (excluding land), depending on the varying design parameters and infrastructure requirements.
- **Charges to the Community:** The facilities are operated through the combination of tax revenue, revenues from the sale of recyclable materials, user fees charged to users of the facilities, and collected rent from Goodwill and other reuse partners. The facilities currently charge $100 per ton for the drop-off of garbage, drywall, yard waste, and wood. There is no charge for reusable goods, tires, electronics, HHW, appliances, metal, or residential recyclables.
- **Arrangement with Service Groups:** Goodwill and community services group pay rent based on 10% of net profit. Goodwill was the successful vendor based on a Request for Proposal.
- **Onsite personnel:** All current facility staff are municipal employees. Operation of the reuse stores and the reuse drop-offs are contracted out. Approximate numbers of staff at the facility each day include 2 scale operators, 2 HHW operators, 1–2 truck drivers, 1 sub-foreman, 1 foreman (shared between two sites), and 3–4 platform laborers.

4.2 RECYCLABLES AND WASTE DROP-OFF

4.2.1 Description

Recyclables Drop-off: Typical household recyclables including paper and cardboard, plus plastic, glass, and metal containers can be commingled and collected in a large open-top bin at the RRP. A separate bin may be provided for oversized cardboard, which is bulky and often collected in greater volume. This is similar to the County's existing drop-bin program. Often the bins are placed at a lower grade to allow residents to drop the materials into the bin and avoid potential injuries from lifting. This service would also be available to small, direct-haul commercial loads of recyclables.

This approach relies on the use of two bins – the first bin being on active duty and accessible to the public, while the second bin is on standby until it is required to replace the active bin. Once the active bin reaches capacity, it can be moved to the MRF to separate and prepare the recyclable materials for market.

HI-5 Redemption Center: All HI-5 certified redemption centers on Kaua'i are operated by private companies. The RRP provides another ideal location for a redemption center, maximizing diversion of these materials and the return of deposit fees to residents. The redemption center must be staffed on a full-time basis. Consequently it is appropriate that it be co-located with the reuse store center activities, likely near the entry to the RRP.

Waste Drop-off: The management of any residual waste that cannot be reused, recovered, or recycled is offered to residents as a final option. An open-top bin is provided to collect the residual wastes. The bins are placed at a lower grade to allow residents to drop or throw the wastes into the bin and avoid injuries from lifting. Once a bin reaches capacity, it is moved to the landfill and a standby bin is put into active duty at the drop-off area. In the future, the County may choose to charge a fee for residual waste drop-off in order to provide further incentive for waste diversion. This is not current policy. If a fee is to be charged, a scale may be required.

4.2.2 Space Requirements

Up to four 40-cy bins (two on active duty and two on standby) are estimated to be required for the receipt and temporary storage of single-stream or commingled recyclables, plus one additional 40-cy bin for oversized cardboard. Six to eight additional 40-cy bins (half on active duty and the others on standby) would be provided for the collection of residential wastes. A 3,000-square-foot (-ft^2) building is proposed for the HI-5 redemption center at the RRP. The collected materials can then be moved to the MRF for processing.

4.2.3 Benefit (Effective Diversion)

The County currently collects approximately 2,700 TPY of recyclables through their current network of drop-off depots (see Table 1). A significant portion of these recyclables are HI-5 materials. It is expected that a large portion of the residential recyclable material would be captured through a curbside collection program in the future, while a much smaller portion may continue to be collected at the existing depots. If the RRP recyclables drop-off replaced only the KRC, it is estimated that approximately 250 tons of recyclables would be received annually. The recyclables received from small, direct-haul commercial generators are expected to increase based on County policies and incentives. It is estimated that these generators may generate a further 250 tons of recyclables annually. Based on these assumptions, it is estimated that the amount of recyclables collected at the RRP drop-off would be approximately 500 TPY.

4.2.4 Capital Cost Requirements

The capital costs associated with the recyclables and waste drop-off are limited to the required bins. For the HI-5 redemption center, an enclosed building is required. These costs are included in the capital costs for the integrated public drop-off and reuse area provided in Section 4.1.

4.2.5 O&M Cost Requirements

The operating costs for the recyclables and residential waste drop-off, including HI-5 redemption center, are included in the O&M costs for the integrated public drop-off and reuse area provided in Section 4.1. The HI-5 center requires a minimum of 3 full-time staff based on existing redemption center requirements.

4.2.6 Comments

The recyclables drop-off area is recommended as a key part of the RRP. It should be one of the initial and most visible activities available at the RRP that can be accessed by the public. A shelter or roof may be incorporated if open-top bins are used, to protect the materials from inclement weather. Adequate fencing or screening to contain blowing litter is recommended.

This service is already provided to the public at the Kauaʻi Resource Center and at the eight drop-bin locations located throughout the island. A private contractor collects the bins when they are full and processes the material for market. The drop-off facilities at the RRP would provide an additional level of service and convenience to waste generators, and potentially allow the replacement of services at the Kauaʻi Resource Center located in Līhuʻe. Materials collected at the RRP drop-off facilities would be transferred to the MRF for processing.

Even once the County implements its planned curbside collection and processing of recyclable materials using a MRF, recyclable drop-off facilities will remain important. For example, recyclable drop-off facilities will remain necessary for those residences generating large volumes or other facilities that are not provided with recyclables collection service. In addition, small commercial generators of recyclables would be able to access the RRP facilities.

4.3 HOUSEHOLD HAZARDOUS WASTE DEPOT

4.3.1 Description

The RRP should include the collection of domestically generated hazardous wastes, limited to household quantities, in accordance with the ISWMP. The County may also wish to accept small quantities of hazardous waste from small businesses and farmers, as appropriate. Typical household hazardous wastes collected include aerosols, batteries, oil, paint, cleaning products, pesticides, and propane cylinders. Other future diversion opportunities identified by the County may include a chemical swap program and paint remixing.

4.3.2 Space Requirements

The HHW collection facility should be sheltered to prevent exposure to climatic conditions that may affect the accumulated materials. A building with an area of approximately 3,000 ft^2 is recommended. As outlined in the ISWMP, it is proposed that an electronic waste depot (Section 4.4) be co-located with the HHW facility. In this case, a total building area of approximately 5,000 ft^2 is recommended. In addition, the area should be secured to prevent unauthorized access when the facility is unattended. A receiving area would be provided to allow the materials to be inspected and a determination made on how they are to be managed prior to bringing the material inside the facility. Sufficient space is required for bulking of materials including paints and flammable liquids. Additional space is required for the wastes once they are properly packed in drums or containers for shipment. The facility should be constructed with non-combustible materials, be properly ventilated, and provide spill containment and fire safety features.

4.3.3 Benefit (Effective Diversion)

Many of these materials may have limited recovery potential, but can be harmful to the environment if disposed of without proper management. Furthermore, elimination of these materials from the landfill improves its leachate quality. An estimated 370 TPY of HHW are generated by residents (approximately 0.35% of the total waste stream).

4.3.4 Capital Cost Requirements

An appropriate building or structure is required to protect the collected HHW materials from inclement weather, prevent unauthorized access, and provide safe storage of materials before and after consolidation. This cost is included in the capital costs for the integrated public drop-off and reuse area provided in Section 4.1 and is estimated at $1,250,000.

4.3.5 O&M Cost Requirements

Due to the nature of the materials being received, the facility must be staffed during operating hours. As materials are received, they are inventoried, segregated, and packaged as appropriate. However, the facility can be operated for as many, or as few days each week or month as required to serve the County's needs. Operation of the HHW depot requires 2 trained full-time staff when operating. These same staff are expected to be able to manage any electronic wastes received at this same location. Additional staff can be added, if warranted in the future, as a function of the number of operating days.

The County's current HHW program costs approximately $53,000 annually for a contractor to consolidate and safely manage the collected material. Most of this cost is for mobilization/ demobilization. As outlined in the ISWMP, future costs will increase but are expected to remain below $100,000 annually for the HHW program.

4.3.6 Comments

The HHW depot is recommended as part of the overall RRP. The County currently offers an annual HHW event at the four County transfer stations. However, a permanent depot would allow the County to provide an improved and expanded level of service. This may include more extensive operating hours/dates and broader services to small businesses and farmers. All aspects of the current program, including collection, packaging, transportation, recycling and disposal of the HHW materials, are provided by a contractor. It is assumed that a private contractor would provide the same service as part of the RRP, and it is assumed that the ultimate recovery or disposal facilities for the HHW would likely remain off-island.

4.4 ELECTRONIC WASTE DEPOT

4.4.1 Description

Electronic waste, including computers, monitors, televisions, telephones, and stereo equipment, would be received by a staff person at the combined HHW (Section 4.3) and electronic waste depot building. The staff would then separate and consolidate the items within a bin or trailer/shipping container, or palletize and shrink-wrap them for shipment. When sufficient quantities of material are collected, the bin, container, or pallet would be transported to a (likely off-island) processor for disassembly (if appropriate), recovery, and safe disposition of hazardous and residual waste materials. The exception to this approach would be for electronic equipment that is still usable and in working order. In such cases, the electrical equipment would be managed through the reuse center at the RRP.

4.4.2 Space Requirements

The electronic waste depot is expected to occupy approximately 2,000 ft^2 within a 5,000-ft^2 building that includes the HHW depot. One or two 20- or 40-foot shipping containers may be required for the receipt/temporary storage of waste electrical and electronic equipment.

4.4.3 Benefit (Effective Diversion)

The County currently collects e-waste during periodic events. In 2011, approximately 100 tons (or less than 0.1% of the total waste stream) of e-waste material was collected through an event, mainly from the commercial sector. By offering a permanent collection service for this type of waste and making the collection more convenient, the amount of diversion achieved is expected to increase. The amount of e-waste collected is expected to be directly proportional to the number of collection days. At the time of this report, the County has put out a bid for collections to occur 2 days per month with an estimated quantity of 300 tons per year of the waste stream being diverted annually.

Diverting additional e-waste may also improve the landfill leachate quality and provide for the recovery of valuable metals.

4.4.4 Capital Cost Requirements

The capital costs associated with the electronic waste depot include the permanent building (shared with the HHW depot) and any required bins. This cost is included in the capital costs for the integrated public drop-off and reuse area provided in Section 4.1 and is estimated at $1,250,000.

4.4.5 O&M Cost Requirements

The operating costs for the electronic waste depot are included in the O&M costs for the integrated public drop-off and reuse area provided in Section 4.1. The electronic waste drop-off would be co-located with the HHW depot (Section 4.3) that can be supervised by 2 full-time staff when operating. The depot is expected to be operated periodically (e.g., 2 days per month). The processing of any collected electronic waste would be undertaken by a contractor.

As discussed in Section 2.1.7, the County has had to subsidize electronics recycling programs since the Hawaii Electronic Waste and Television Recycling and Recovery Law (HAR Title 19, Chapter 339D) went into effect. The electronic waste depot at the RRP could provide a convenient, central location for electronic waste recovery, fulfilling the County's commitments. It is expected that the

County will incur public outreach, marketing, and related costs estimated to be approximately $80,000 annually.

4.4.6 Comments

The approach taken may be dictated by the end market for the materials and the preference for the electronic waste to be segregated by specific category.

Annual collection of electronic waste is already provided by the County through a private contractor. It is assumed that a private contractor would provide the same service as part of the RRP. Some of these materials are also collected from the public through non-governmental organizations.

4.5 METALS RECYCLING FACILITY

4.5.1 Description

The County currently contracts metal-recycling operations with the PMRC, which accepts a range of scrap metals for processing, including automobiles, white goods, propane tanks and other metal scrap (Section 2.1.6). The scrap metals are accepted, processed, and prepared for market. The PMRC is operated by a private contractor and is situated on private land under a lease agreement. The County plans to provide space at the RRP for potential development of a metals recycling facility with operations similar to those conducted at the PMRC. The County has available various procurement options for the development and operation of the proposed facility. The capital cost of this facility may or may not be funded by the County. Estimated costs are provided in this section for completeness.

Household scrap metal is typically generated in small quantities either during renovation projects or via disposal of appliances and propane tanks. An open-top bin can be provided to collect the smaller scrap metal pieces. Propane tanks would be collected and stored within a secure area near the HHW facility and moved to the processing area to be decommissioned. Appliances or white goods could be accepted at a hard-surfaced drop-off area, or could be accepted at the metals processing area. The appliances containing refrigerants would be segregated from those appliances that do not contain refrigerants. The refrigerants must be properly removed before processing. When sufficient quantities of metals or appliances are collected, they would be moved to the processing area for proper management. Scrap vehicles would be sent directly to the processing area.

At the processing area, any liquids would be drained, and then the scrap metal, white goods, and vehicles would be compacted and baled for shipment to market.

4.5.2 Space Requirements

The existing PMRC operates on a site area of approximately 5.5 acres, and a similar area would be required at the RRP. One 40-cy bin would be required for the receipt/temporary storage of small- to mid-sized scrap metal items in the integrated public drop-off area. A larger laydown area of approximately 5,000–10,000 ft^2 would be provided for the collection of heavier materials such as automobiles and appliances. This laydown area would be located adjacent to the onsite scrap metal processing area. The onsite processing area would be available at the RRP to consolidate and process scrap metals prior to shipment to market. An area of 0.15 acre would be required for the scrap metal processing line. Additional equipment required to crush used automobiles can be relocated from the PMRC or can be provided by the contractor that operates the metals recycling facility.

4.5.3 Benefit (Effective Diversion)

County data indicate that approximately 4,669 tons of all metal types were processed in FY2011. The collection and processing of these materials represents approximately 4.4% diversion (conservative estimate). This rate of diversion is expected to remain relatively constant in the future, as this is already a well-established program that would be relocated to the RRP.

4.5.4 Capital Cost Requirements

The capital costs associated with the scrap metal drop-off are limited to the required bin, a secure area adjacent to the HHW depot for propane tanks and a small paved drop-off area for white goods. This cost is included in the capital costs for the integrated public drop-off and reuse area provided in Section 4.1.

The required metals processing facilities would include a 5.5-acre hard-surface area plus the scrap metal processing equipment. The capital costs associated with this component of the RRP are estimated to be approximately $1.5–$2 million. A facility schematic showing the equipment and infrastructure included in the white goods and metals shredding and baling system is presented in Appendix A (Figure A-1).

4.5.5 O&M Cost Requirements

The operating costs for the metals recycling facility include two components. The scrap metal drop-off is included in the O&M costs for the integrated public drop-off and reuse area provided in Section 4.1. The scrap metal waste drop-off (for small quantities only) can be co-located with other drop-off facilities, which together can be supervised by 1–2 full-time staff.

The processing of any collected scrap metal would be undertaken by a contractor, similar to the existing PMRC. This includes the provision of all labor and equipment to process the scrap metal material. The annual cost of this contract in 2011 was approximately $560,000. Based on the volumes to be managed staying fairly constant in future years, these annual costs should not change substantially. These costs agree well with the estimated costs based on component operations: the O&M cost for the scrap metal processing line is estimated to be approximately 10% of the capital cost plus labor ($240,000 annually plus labor); and the used car crusher is expected to have comparable or greater O&M costs (approximately $300,000 annually plus labor). The scrap metal processing line would require 2 full-time staff.

4.5.6 Comments

The metals recycling facility is recommended as part of the RRP. The County currently accepts white goods at the four transfer stations and at Kekaha MSWLF. The PMRC separates, processes, and recycles a range of scrap metal materials. The service is currently provided by the County under a private contract, and it is assumed that a private contractor would provide the service as part of the RRP.

4.6 Construction and Demolition Material Processing and Recycling Facility

4.6.1 Description

C&D material can include a range of materials. The most common and largest quantity of materials includes concrete, brick, block, and asphalt, treated and untreated lumber, plaster board or drywall, cabinets, doors, windows, roofing, and soil. A series of open-top bins can be provided to collect small quantities of these separated materials. When sufficient quantities of C&D material are collected, the bins or containers would be moved to a separate processing area at the RRP. Any source separated loads of C&D material from residential and commercial generators would be diverted to the processing area for direct placement into bins or bunkers. The County plans to provide space at the RRP for potential development of a C&D processing and recycling facility. The County has available various procurement options for the development and operation of the proposed facility. The capital cost of this facility may or may not be funded by the County. Estimated costs are provided in this section for completeness.

4.6.2 Space Requirements

Up to three 40-cy bins would be required for the receipt and temporary storage of residential C&D material, including wood and drywall, in the integrated public drop-off area. It is anticipated that the majority of C&D material would be generated by commercial sources and would be delivered in larger quantities directly to a processing area at the RRP. An estimated site area of approximately 1 acre would be required to receive, consolidate, and process construction waste materials. A facility schematic showing the equipment and infrastructure included in the C&D Processing Area is presented in Appendix A (Figure A-2).

An area of approximately 0.84 acre would be provided for stockpiling/temporary storage of concrete, brick, block, and asphalt. This material would be received mainly from commercial sources.

4.6.3 Benefit (Effective Diversion)

The available waste composition data suggest that just over 5,000 TPY of C&D material are generated on Kauaʻi; not all of this material would be suitable for recovery at the RRP. Recent observations by County staff suggest that more C&D material than that amount – i.e., approximately 16,000 TPY, or nearly 15% of the annual waste stream – may actually be generated. This amount includes 3,000–4,000 tons of concrete/brick/block and asphalt, which is currently processed (crushed and size classified) by Pacific Cutting & Coring. A further 10,000–12,000 tons of other C&D materials are disposed of at the County's landfill. The composition of these wastes and quantity estimates were determined based on a visual/qualitative assessment by County staff of C&D materials entering the Kekaha MSWLF between April and July 2011.

The strategy to divert C&D material from disposal consists of a combination of programs/policy instruments, service contracts and infrastructure potentially developed in two phases. More specifically, this component would consist of the following:

Phase 1 C&D processing facility: A waste ordinance would dictate that C&D waste materials be source-separated at construction/demolition sites as clean loads of mixed rigid and film plastics, clean drywall, mixed scrap metal, uncontaminated wood, pallets, old corrugated cardboard (OCC), and small quantities of concrete brick and block. These clean loads would be delivered to an area on the RRP site consisting of a concrete slab complete with dedicated storage bunkers constructed out of stacked mass concrete blocks (dedicated bunker for each material). Once a sufficient quantity of any one of these material has accumulated to justify shipping, the material would be top-loaded into roll-offs or trailers and shipped to market. This is referred to as the Phase 1 C&D processing facility.

Phase 2 C&D sorting facility: In the event that the waste ordinance regarding source separation does not yield the desired result, the County may implement the second phase of this facility, which would consist of a C&D sort line to process mixed C&D materials.

As it relates to the 3,000–4,000 tons of concrete/brick/block and asphalt materials, the County would continue to rely on a private company to process this material. However, it is proposed that an area be reserved at the RRP site for the stockpiling/temporary storage/onsite contracted processing of up to 5,000 tons of this material. A contractor with portable crushing/screening equipment would mobilize to the site at least three times per year to process the materials. This service approach applies to both Phase 1 and 2 C&D processing operations as described above.

4.6.4 Capital Cost Requirements

The equipment and associated infrastructure required for processing the estimated quantities of C&D material has an approximate capital cost of $1.43 million for Phases 1 & 2, as shown in Table 26. The equipment could be purchased and installed in phases as described above.

Table 26: Estimated Capital Costs for C&D Material Processing and Recycling Facility

Item	Cost ($, rounded)
Phase 1	
Site preparation, granular base, concrete slab	$100,000
Storage bunkers	$65,000
Miscellaneous and Contingencies (20%)	$35,000
Total Phase 1	**$200,000**
Phase 2	
Site preparation, granular base, concrete slab	$150,000
Process related storage bunkers	$75,000
Processing system (freight, supply, install)	$800,000
Miscellaneous and Contingencies (20%)	$205,000
Total Phase 2	**$1,230,000**

4.6.5 O&M Cost Requirements

The O&M cost is estimated to be up to $869,000 annually once Phase 2 of the processing has been implemented. A breakdown of the O&M costs is provided in Table 27. One staff person would be required during Phase 1, increasing up to 12 staff if Phase 2 of the processing facility is implemented.

Table 27: Estimated Operating Costs for C&D Material Processing and Recycling Facility

Item	Annual Cost ($, rounded)
Phase 1	
Front-end loader lease @$3,000/month	$36,000
Equipment operators	$45,000
General laborer	$30,000
Miscellaneous and Contingencies (20%)	$22,000
Total	**$133,000**
Phase 2	
Phase 1 operating cost	$133,000
Sorters – 12 staff @ $30,000 per year	$360,000
Processing mechanical O&M @15% of equipment capital	$120,000
Miscellaneous and Contingencies (20%)	$123,000
Total	**$736,000**

4.6.6 Comments

C&D material is not currently collected by the County for recycling. Consistent with how other services are provided by the County, it is assumed that a private contractor would provide C&D material recycling service as part of the RRP. Depending on the actual quantity of these waste materials generated within the County, a significant contribution can be made to diversion overall.

4.7 USED TIRE PROCESSING FACILITY

4.7.1 Description

The majority of used tires from passenger vehicles on Kaua'i are typically managed through the commercial service centers where new tires are installed. Industrial tires and tires from non-residential sources are accepted directly by local private businesses. The County currently accepts used tires from residents at all transfer stations and the landfill. The used tires are then managed by a private contractor. The used tires are typically shipped off-island, where they are shredded and burned as a fuel source. For those tires not collected by these methods, an open-top bin can be provided to collect tires at the RRP. When sufficient quantities of tires are collected, the bin or container can be moved to a processing area at the RRP.

The County proposes to include a processing area at the RRP for used tires that includes capacity to manage all used tires generated in the County. This is estimated to be approximately 70,000–80,000 tires per year. The County has available various procurement options for the development and operation of the proposed facility. The capital cost of this facility may or may not be funded by the County. Estimated costs are provided in this section for completeness.

4.7.2 Space Requirements

One 40-cy bin would be required for the receipt and temporary storage of used tires in the integrated public drop-off area. An onsite processing area would be available at the RRP to consolidate and process used tires prior to shipment to market. It is proposed that a vertical downstroke baler be used. The baler would be positioned on a concrete slab in a 1,000-ft^2 sprung-steel, fabric-covered building with an open area located adjacent to the building for up to 1 week's storage of loose tires. The loose tire storage area may be covered should rainwater collect in tires and create a breeding habitat for mosquitoes. A site area of approximately 0.4 acre would be required at the RRP, mainly for storage of the loose and baled tires, and also an area for the tire baler. A facility schematic showing the equipment and infrastructure included in the tire baling system is presented in Appendix A (Figure A-1).

4.7.3 Benefit (Effective Diversion)

In 2011, the County received approximately 13,700 used tires to be managed. The estimated 70,000–80,000 used tires generated annually in the County could be managed through the RRP in the future. Data are not available to identify the percentage of the waste stream or estimate diversion achieved. It is estimated that used tires account for less than 1% of the waste stream directed to disposal, and that effectively 100% of used tires are being captured and diverted by the current recovery system. Tires are banned from landfill disposal in the County.

The baler operates on a batch load basis and is loaded manually. Each tire bale consists of 90–110 vehicle and light truck tires per bale. The facility would have the capacity to process up to 400 tires per day and produce 4 bales daily.

4.7.4 Capital Cost Requirements

The capital costs associated with the used tire drop-off are limited to the required bin. This cost is included in the capital costs for the integrated public drop-off and reuse area provided in Section 4.1.

The used tire processing facility would be located adjacent to the other RRP processing areas. The capital costs associated with this component of the RRP are estimated to be approximately $252,000. A breakdown of the costs is provided in Table 28.

Table 28: Estimated Capital Costs for Used Tire Processing Facility

Item	Cost ($, rounded)
Site preparation, granular base, concrete slab	$35,000
Vertical downstroke baler	$75,000
Sprung steel fabric covered structure (25 ft × 25 ft)	$100,000
Miscellaneous and Contingencies (20%)	$42,000
Total	**$252,000**

4.7.5 O&M Cost Requirements

The operating costs for the used tire processing facility include two components. The used tire drop-off is included in the O&M costs for the integrated public drop-off and reuse area provided in Section 4.1. The used tire drop-off (for residential users only) can be co-located with other drop-off facilities, which together can be supervised by 1–2 full-time staff.

The processing of any collected used tires would be undertaken by a contractor. The County currently contracts the processing and marketing of all used tires collected at their transfer stations. This includes the provision of all labor and equipment. The annual cost of this contract in 2011 was approximately $90,000.

The O&M cost for the proposed used-tire baling is estimated to be approximately $165,000 annually. An estimated 2 staff would be required.

4.7.6 Comments

Used tire collection is recommended as part of the overall RRP, and onsite processing would involve baling and shipping off island to market. The County currently accepts tires at all transfer stations and at the Kekaha MSWLF. The collected tires are then processed by a contractor. It is assumed that a private contractor would provide the same service as part of the RRP. The RRP would have the capacity to manage 70,000–80,000 tires per year.

4.8 Center for Hard-to-Recycle Materials

4.8.1 Description

Hard-to-recycle materials, typically generated in small quantities, include materials for which there are very limited markets and secondary uses. Some mainland municipalities also define hard-to-recycle materials to include such materials as HHW, e-waste, C&D materials, and tires. However, the County has identified that opportunities to divert many of these materials do exist, and the approach to divert these materials through the RRP has been described previously. Consequently for the Kaua'i RRP, hard-to-recycle materials may include but would not limited to certain types of plastics, such as large durable #2 and polystyrene, foam blocks, plus various household items including textiles, hard cover books, and mattresses. These materials would be collected, segregated, and stored at a covered or enclosed building. It is proposed that this area be co-located with the reuse center.

Depending on the availability of markets for the collected materials, when sufficient quantities of materials are collected, staff would then place the collected material into a bin, or package as appropriate. The bin or container is then sent to the end market for processing. The types of materials managed through this center may change as economical markets and sufficient material volumes are identified. As markets and waste volumes permit, it is assumed that a private contractor would provide this service, potentially in conjunction with the reuse program.

4.8.2 Space Requirements

An 11,000-ft^2 building is proposed for the reuse center at the RRP and would include the center for hard-to-recycle materials.

The various materials would be sorted and consolidated prior to shipment to market. An area to store these materials would be located within the building or in covered bins outside the building. A site area of approximately 0.5 acre would be required at the RRP, mainly for the outside storage of these materials.

4.8.3 Benefit (Effective Diversion)

Data are not available to identify the percentage of the waste stream that is defined as hard-to-recycle material. It is estimated that these materials account for less than 1% of the waste stream, and that the majority of large-volume recyclable material would be captured and diverted through the other programs provided at the RRP. However, should new markets become available, the opportunity to divert additional materials should be pursued by the County.

4.8.4 Capital Cost Requirements

The capital cost associated with the hard-to-recycle drop-off would be limited to the required building, shared with the reuse center. This cost is included in the capital costs for the integrated public drop-off and reuse area provided in Section 4.1.

A storage area for consolidated materials would be located adjacent the building. It is recommended that no more than 3–5 bins be provided for this type of storage.

4.8.5 O&M Cost Requirements

The operating costs for the hard-to-recycle materials include two components. The hard-to-recycle materials drop-off can be co-located with the reuse center, which together can be supervised by 3-4 full-time staff. Therefore, the drop-off for these materials is included in the O&M costs for the integrated public drop-off and reuse area provided in Section 4.1.

Based on the relatively small volumes and specific material types, it is assumed that the assigned staff will also market any collected hard-to-recycle materials. This onsite processing is expected to be limited to the physical separation of collected materials as received for consolidation by material type and packaged for shipping as required. The annual cost of labor and shipping of hard-to-recycle materials is estimated to be approximately $100,000. Based on the volumes to be managed staying fairly constant in future years, these annual costs should not change substantially.

4.8.6 Comments

A center for hard-to-recycle materials is recommended as part of the overall RRP. The hard-to-recycle materials center at the RRP would focus on items such as large durable #2 and polystyrene plastics, foam blocks, and various household items including textiles, hard-cover books, and mattresses. Markets are generally very limited for these materials or are not yet fully developed. It may be necessary to store these materials for a period until markets do become available or an adequate volume of material has been accumulated.

4.9 Reuse Center

4.9.1 Description

Direct, local reuse of items can be considered the highest-value waste diversion process, as it is the least resource- and energy-intensive option, encourages local direct reuse, and displaces the purchase of new items. A reuse center typically provides an opportunity for the exchange of second-hand or gently used items. This can include clothing, furniture, computers, sporting equipment, houseware, and building materials. Generally, the items must be clean and in good working condition. These materials are received from the public and then resold as-is for a fee. Some higher value items may be repaired or refurbished by staff in order to enhance the potential reuse of the item. These types of facilities are commonly operated by non-profit organizations including Goodwill and Habitat for Humanity.

It is proposed that the center for hard-to-recycle materials (Section 4.8) be located at the reuse center. The County plans to provide space at the RRP for potential development of a reuse center that can be operated in a manner consistent with existing non-profit facilities within the County. The capital cost of this facility may or may not be funded by the County. Estimated costs are provided in this section for completeness

4.9.2 Space Requirements

The reuse center component of a RRP is typically an enclosed facility located near the entrance. It is often the first stop for any visitors to the RRP. The building is sized based on the projected quantity of material that would be managed and on the period that materials would be held. Adequate parking space is also required. An 11,000-ft^2 building is proposed for the reuse center at the RRP. The building would also provide sufficient space for the center for hard-to-recycle materials (Section 4.8) at the RRP.

4.9.3 Benefit (Effective Diversion)

A number of community-based reuse programs currently operate within the County. Data are not available to identify the percentage of the waste stream that is defined as reusable. It is estimated that these materials account for less than 1% of the waste stream. Education and promotion of this service are key to maximizing the capture and diversion of these types of materials at the RRP. The proposed facility is intended to enhance the opportunity for reuse within the County by supporting activities like the refurbishment of damaged items such as bicycles, furniture, and even electronics. This would add value, provide a new service, and create jobs.

4.9.4 Capital Cost Requirements

The capital costs associated with the reuse center include the enclosed building and associated paved parking area. These costs are included in the capital costs for the integrated public drop-off and reuse area provided in Section 4.1.

4.9.5 O&M Cost Requirements

The operating costs for the reuse center are included in the O&M costs for the integrated public drop-off and reuse area provided in Section 4.1. This facility would require 3–4 full-time staff in conjunction with the operation of the reuse center.

4.9.6 Comments

The reuse center is recommended as a key component of the RRP, as it provides a visible and tangible opportunity for waste diversion among residents. It offers the ability to obtain goods or materials at a reasonable price while supporting diversion from disposal.

4.10 Educational Center

4.10.1 Description

The educational center is typically set up in a boardroom style meeting room to support large group presentations and interactive discussions. The center can serve as a staging area for groups before receiving a tour of the RRP. In the event the center is expected to support school tours, it may be sized for approximately 60 students or the equivalent of two classes.

Work stations can also be provided at the educational center to support research that may be ongoing at the RRP related to its various components including composting, energy production, technology evaluation, and monitoring.

4.10.2 Space Requirements

The educational center component of a RRP is often co-located with another enclosed building on the RRP. It is proposed that a meeting room and an elevated glassed-in viewing area be provided at the MRF to facilitate educational functions and tours. Washroom facilities and adequate parking would also be required.

4.10.3 Benefit (Effective Diversion)

The educational center does not directly result in waste diversion. A strong promotion and education component is essential to the overall success of the RRP and its individual programs and facilities. The education center would be set up to support interactive discussions and training related to recycling and waste diversion, and support facility tours to provide residents with a better understanding of the programs and facilities available at the RRP and how they work. Education and promotion are key to maximizing the capture and diversion of all recyclable materials at the RRP, and therefore the education center may indirectly bolster all of the County's diversion efforts.

4.10.4 Capital Cost Requirements

The educational center infrastructure (i.e., the meeting space/building and associated paved parking area) would be combined with the material recovery facility. These costs, in turn, are included in the capital costs for the MRF provided in Section 4.11.

4.10.5 O&M Cost Requirements

The operating costs for the educational center include one full-time County staff. This person would provide an overview of all County diversion efforts along with tours of the RRP and associated facilities and operations. They can also support other educational and promotional tasks for the County.

4.10.6 Comments

The educational center is recommended as a key component of the RRP, as it provides the opportunity to discuss directly with residents, businesses, trade associations, community groups, schools, visitors, legislators, and others the benefits of waste diversion and the programs offered at the RRP. These discussions can then be reinforced by providing guided tours of the RRP and its operations.

4.11 MATERIALS RECOVERY FACILITY

A conceptual design of the proposed materials recovery facility (MRF) is presented below, outlining in general terms the features and capital and operating costs.

4.11.1 Description

A MRF is a processing facility that receives collected recyclable materials, sorts the materials based on type, removes any contaminants, densifies the materials, and then bales them into a form suitable for transport and sale to markets. Recyclable materials available to the County as feedstock for a MRF are available from both residential (Section 3.4.1.1) and commercial (Section 3.4.1.2) sources.

Figure 2 shows the conceptual facility layout.

4.11.1.1 Process Description

The recommended MRF facility consists of a single-stream sorting system with a 10 tons/hr capacity. Major features include:

- Two options for an in-feed conveyor (either an in-floor conveyor or a conveyor and storage hopper arrangement mounted on the slab).
- Three pre-sort stations for removal of OCC, film, large rigid plastics, and trash.
- Glass breaker screen to screen out glass as <2-inch fraction. Glass falls into a bunker or roll off below the pre-sort station.
- Disc screen to separate containers from fibers. Containers are generally 3-dimensional items; fibers (paper) are generally 2-dimensional items. The large fiber materials rise over the top of the disc screen onto a Fiber Quality post-sort line, where small OCC, film, and containers are removed to produce a mixed paper stream. Two bunkers are dedicated to the interim storage of the mixed paper fraction prior to baling.
- Containers fall through the screen onto a transfer conveyor to the "container-line." The transfer conveyor passes by a fiber post-sort station to allow for manual fiber removal prior to the container sort line.
- Container sort line includes:
  - Magnetic separator to remove ferrous material
  - Eddy current separator to remove aluminum
  - Six push-through style manual sort bunkers for: steel, PET, HDPE, and aluminum (an eddy current separator could be added as an option) and two spare bunkers in case it is decided to sort HDPE by color and expand the program to include #3–#7 Plastics.
  - Push-through bunkers onto baler feed conveyor
  - Compactor for residual material
- Two-ram baler to bale both the fibers and containers
- OCC manually diverted from the waste stream and either floor-sorted or removed off the pre-sort station

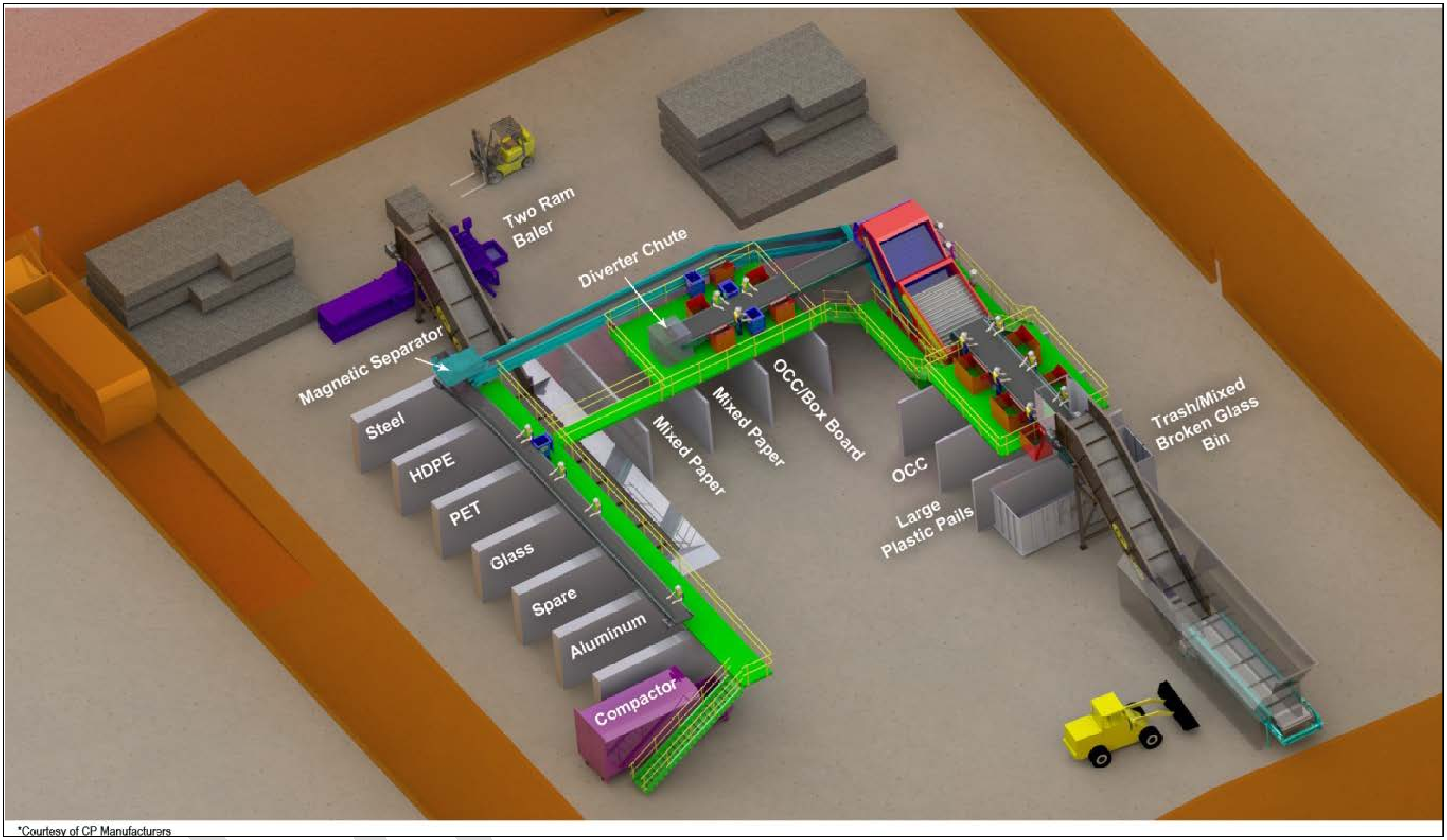

Figure 2: Conceptual MRF Design

4.11.1.2 Recommended MRF Capacity

In order to size (and cost) the proposed MRF facility, the following design values are considered, based on the data in Section 3.4.1.1.1:

1. Lower bound. The optimistic estimate for recovery of curbside-collected residential materials with no recovery at all from the commercial sector, at the end of the planning period, is 7,682 TPY, which sets the lower bound of the design capacity.
2. Projected upper bound. The estimated recovery from the commercial sector at the end of the planning period is 14,265 TPY. Adding this to the upper limit of the residential figure of 12,418 TPY results in a total expected capacity of 26,683 TPY at the end of the planning period, which sets the projected upper bound of this design.

A typical smaller-scale, commercially available single-stream MRF is designed to process approximately 10 tons/hour. Based on a typical 7-hour shift, such a facility would process 70 tons per shift. In order to process the lower bound (residential) quantity (7,682 TPY), this facility would require 110 shifts annually. This equates to the facility operating for one shift per day, for approximately 2.1 days per week, over the course of a 52-week year.

Similarly, processing the projected upper bound quantity (26,683 TPY) would require 361 shifts per year. This equates to the facility operating for one (8–9 hour) shift per day, for approximately 6 days per week, over the course of a 52-week year. Therefore, this facility would be well-sized to meet the expected upper-bound design capacity.

4.11.2 Space Requirements

The overall MRF building dimensions are approximately 225 ft × 150 ft × 28 ft height. It includes the following:

- Two overhead doors to receive materials
- Two depressed loading docks to load recovered materials
- Two overhead doors to facilitate the removal of roll-off bins

Included in the interior of the process building is a combined elevated glass enclosed walkway and classroom to facilitate educational tours, as well as a single-story office area (3,000 ft^2) constructed out of architectural block.

The overall site area is approximately 5 acres in size and includes a dedicated single-deck scale, scale house, and storm water detention pond (if not collocated at the landfill). Site roads would be paved, and the site would be fenced. It is assumed that adequate sewer, potable water, and electrical supply are available at the site boundaries.

4.11.3 Benefit (Effective Diversion)

The lower-bound recovery estimate of 7,682 TPY amounts to approximately 5% of the County's overall waste stream. The upper-bound recovery estimate of 26,683 TPY amounts to approximately 17% of the County's overall waste stream.

Even if the MRF fully captured all of the recyclables in the island's waste stream (37,400 TPY, the upper-bound ideal case that will not be entirely realized), this facility could operate for 624 shifts per year. This equates to the facility operating for slightly more than two shifts per day (each at 7 effective processing hours per shift), 6 days per week, over the course of a 52-week year. Therefore, under any conceivable scenario, this facility would be capable of processing all of the county's recyclables, and still allow for down-time on the weekends for maintenance and repairs. Operating at 10 tons/hour, this system equates to a capability of processing 43,680 tons/year.

The proposed MRF layout will enable future upgrade to increase system capacity and/or output cleaner product. For example, if an additional fiber screen were added, it would enable the production of separate newspaper and mixed-paper material streams. As presently configured, a single mixed-paper stream would be produced.

4.11.4 Capital Cost Requirements

Table 29 summarizes the estimated capital costs to design, permit, build, and equip the MRF.

Table 29: Estimated Capital Costs for MRF

Item		**Cost ($, rounded)**	**Basis/Description**
Contract Requirements		$50,000	Allowance
Design, Permitting, & Procurement		$350,000	Allowance
Site Development		$675,000	Site grading & drainage, site roads, fencing, site services (allowance)
Buildings	Pre-engineered building	$2,813,000	Building footprint: 225 ft × 125 ft = 28,125 ft^2; Building height: 28 feet Includes: • Two overhead doors to receive materials • Two depressed loading docks to enable shipping of recovered materials • Two additional overhead doors to enable removal of various roll-off bins • Elevated MRF viewing area to facilitate facility tours (Unit Cost $100.00/$ft^2$)
	Attached office	$450,000	Single-story architectural block office/washroom/ change area (3,000 ft^2; attached to Pre-engineered process building), with an estimated unit cost of $150/$ft^2$. May be shared with other facilities, possibly including the landfill.
Mechanical Equipment	Fixed-process MRF mechanical equipment	$2,500,000	Includes purchase, shipment, and installation.
	Front end loader	$125,000	
	Fork lift	$50,000	
	Scale & scale house: $200,000	$200,000	May not be required if co-located at landfill.
Subtotal		*$7,213,000*	
Miscellaneous and Contingencies		$1,443,000	20%
Total		**$8,656,000**	

4.11.5 O&M Cost Requirements

Table 30 summarizes the estimated planning-level labor and other miscellaneous operating costs associated with the facility. The projected operating costs presented in this report are based on the assumption that the facility will process the projected upper-bound quantity, or approximately 26,683 TPY of combined residential and commercial recyclable materials.

Table 30: Estimated Operating Costs for MRF

Category	Expense	Annual Cost ($, rounded)
Labor	1 - Facility manager	$55,000
	1 - Receptionist/materials sales	$35,000
	1 - Supervisor/Mechanic	$50,000
	1 - Scale house operator	$35,000
	1 - Equipment operator	$45,000
	10 - Sorters (2 on pre-sort, 2 on the fiber line, 6 on the container line) @ $30,000 each	$300,000
	Sub-total	$520,000
	Fringe @ 30%	$156,000
	Total Annual Manpower Costs	*$676,000*
	Profit on Labor @ 20%	*$135,000*
Other Miscellaneous Costs	Baling wire	$15,000
	Fuel for loader and forklift	$25,000
	Computers, printers, phones	$5,000
	Insurance	$25,000
	Utilities	$35,000
	Landscaping	$10,000
	Dust control	$10,000
	Janitorial	$5,000
	Security	$5,000
	Total Miscellaneous Costs	*$135,000*
Estimated Total Annual Operating Costs		**$946,000**

The materials received and processed at the MRF do have an inherent value that can be utilized to offset operating costs. With the exception of the HI-5 materials, these are commodities that can be subject to wide variations in market values. A revenue estimate is best developed and budgeted when the program is better defined in order to address these fluctuations.

4.11.6 Comments

A material recovery facility is recommended as part of the overall RRP. Upon finalization of this FS and selection of a site for the RRP and MRF, a more detailed site-specific design, and associated costs, can be developed.

The County intends to implement a series of supporting policies and programs to support their aggressive approach to meeting a 70% waste diversion target. These initiatives may be implemented in phases and are also expected to take some time to become completely effective and adopted within the community. Consequently, to minimize some of the financial risks, the County may choose to implement the MRF through a phased approach.

4.12 COMPOSTING FACILITY

The ISWMP contained a number of recommendations related to improved diversion of organic materials, including:

- Establish an automated weekly, curbside collection system for greenwaste.
- Provide curbside collection for pre-consumer organics.

- Expand the ban on municipal landfill disposal of non-residential greenwaste to include residential waste, and expand the ban to include disposal restrictions at the transfer stations.
- Establish a central greenwaste and organics processing facility to produce mulch or compost.

Compost can be created aerobically or anaerobically. Aerobically produced compost simply means that oxygen is present in concentrations that enable the growth of beneficial, aerobic organisms. Anaerobic conditions refer to there being limited oxygen in the windrow. These conditions facilitate the growth of anaerobic organisms, which tend to be pathogenic (disease-causing) and are therefore not recommended for application to soil and for plant growth. As a guide, the following lists the oxygen concentrations in aerobic and anaerobic compost.

- Equal to or greater than 6 ppm O_2 = aerobic
- Equal to or less than 4 ppm O_2 = reduced O_2
- Less than 4 ppm O_2 = Anaerobic

As such, the oxygen content for creating aerobic compost needs to be equal to or greater than 6 ppm.

Based on the implementation of these diversion activities, Section 3.4 presents the projected estimate of the available quantities of organics that may be available over the planning period, which forms the basis of design for the composting facility. It is estimated that approximately 33,812 TPY of organic material may be captured and diverted by the end of the 20-year planning period (Table 24). This represents approximately 21% of the total waste stream. Organic materials could be processed either aerobically (below) or anaerobically (Section 4.13) at the RRP.

4.12.1 Description

Greenwaste Drop-off: Greenwaste, including lawn and tree trimmings and other organic yard and garden waste, are typically high-volume and bulky wastes. Greenwaste can be placed directly into a large open-top bin or onto a graded pad. When a bin is utilized, a standby bin must also be available for use when the active bin reaches capacity. However, it is more common to provide a drop-off pad for this waste type. The accumulated greenwaste is then consolidated and loaded into a truck or bin using a front end loader. The greenwaste drop-off area should provide adequate space for larger vehicles and trailers, which are typically used by residents and commercial service providers for transporting this material to the RRP. A compacted surface for the pad area is necessary for the loader to operate on.

The collected greenwaste material would be periodically transported to an area of the RRP where it would be managed further, possibly including grinding or shredding and composting (discussed below).

Greenwaste drop-off service is already provided by the County to the public at the existing four transfer stations and landfill site. The County contracts with private contractors to manage and process collected greenwaste. The proposed composting facility at the RRP has been sized to provide sufficient capacity for processing this material, if necessary.

While the County may implement the curbside collection and processing of greenwaste materials (using a processing facility to be constructed at the RRP) from single-family residences, a greenwaste drop-off facility at the RRP (and other existing collection sites) will remain important to manage large bulky green items and seasonal overflow conditions that cannot be serviced by curbside collection.

Aerobic Processing of Organics: In 2008, while preparation of the ISWMP was still underway, the County commissioned a study entitled *Centralized Composting Facility Master Plan* (Beck 2008) (herein referred to as the Composting Study). The Composting Study contained detailed implementation and cost estimates associated with the phased development of the recommended centralized greenwaste and organics processing facility.

A range of aerobic composting alternatives were identified based on the types of organic materials to be combined and processed. The alternatives included windrow composting, aerated static piles, in-vessel, and covered aerated piles or windrows. Each of these approaches to composting involves the addition of oxygen and water to the organics material in a controlled manner to support the decomposition of waste. The specific choice of an alternative is typically determined based on the type of organic materials available, carbon and nitrogen content, the porosity of the ingredients, and the potential for offensive odor generation.

The Composting Study recommended that the County begin with windrow composting of greenwaste and then transition to an aerated static pile once biosolids and food wastes were introduced. It may be necessary, depending on the quantity, quality, and relative proportion of these materials, for this strategy to evolve from aerated static pile to a system that provides greater process control.

Figure 3 depicts the overall windrow composting process, and Figure 4 shows a conceptual layout of a typical windrow composting facility.

4.12.2 Space Requirements

The minimum total area required to support windrow composting, storage of composted material, and buffer areas for the projected quantities is estimated at 9 acres. The specific space requirements will be determined for the Final FS, once the overall site layout is known and the quantity of organic material to be received from the private sector is confirmed, as this is the majority of the greenwaste generated. Among other things, the fee charged by the County for processing organic waste may affect the quantity of material received.

4.12.3 Benefit (Effective Diversion)

An aerobic compost facility employing windrows could process the estimated 33,812 TPY of organic waste that may be captured (i.e., 21% of the County's waste stream) by the end of the planning period (see Table 24).

4.12.4 Capital Cost Requirements

Capital costs to construct this facility and purchase associated equipment would be approximately $3 million. Capital costs for the proposed aerobic composting facility were previously provided in the Composting Study. These costs have been reviewed and are updated as appropriate in Table 31.

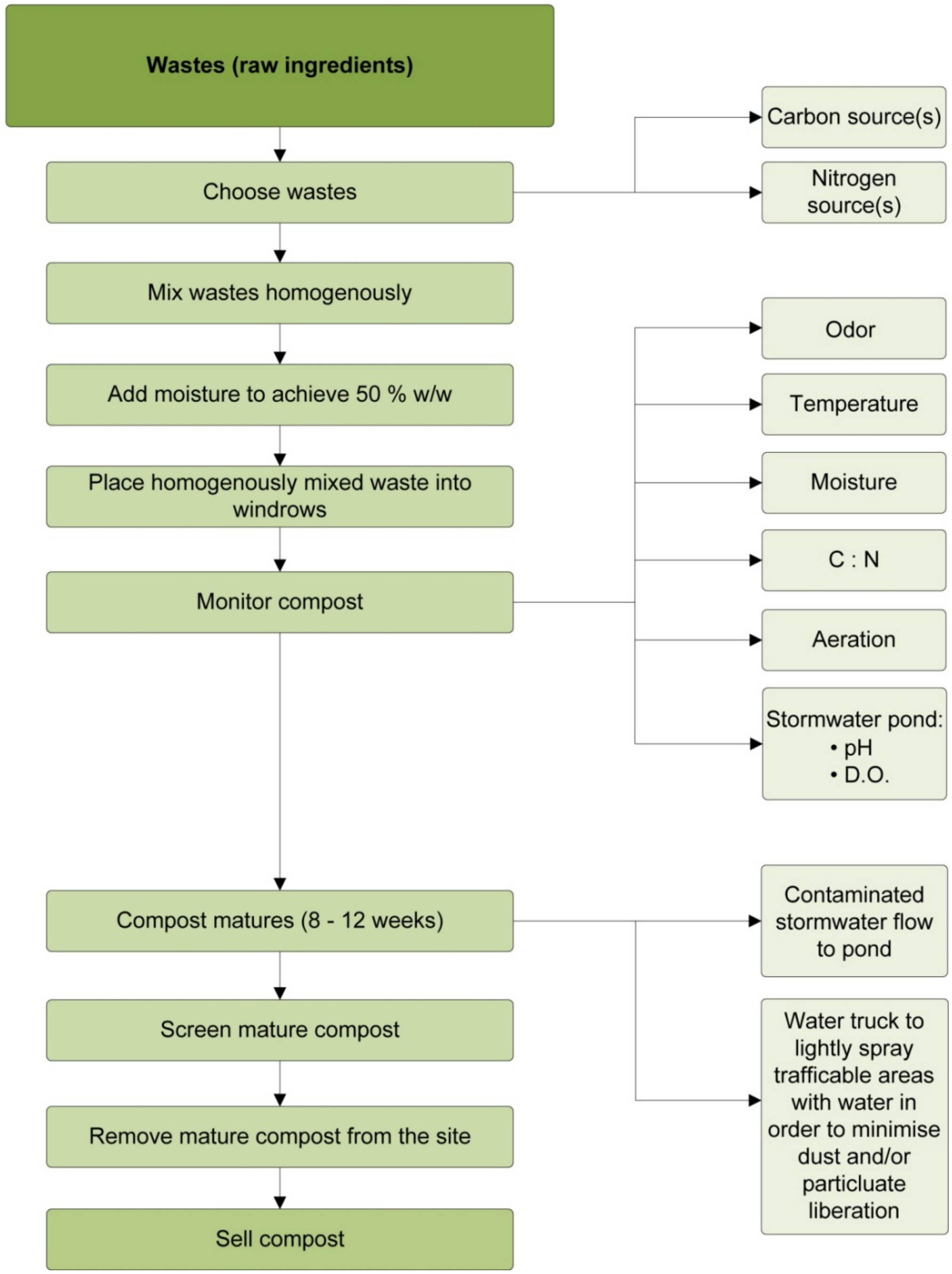

Figure 3: Overall Composting Process

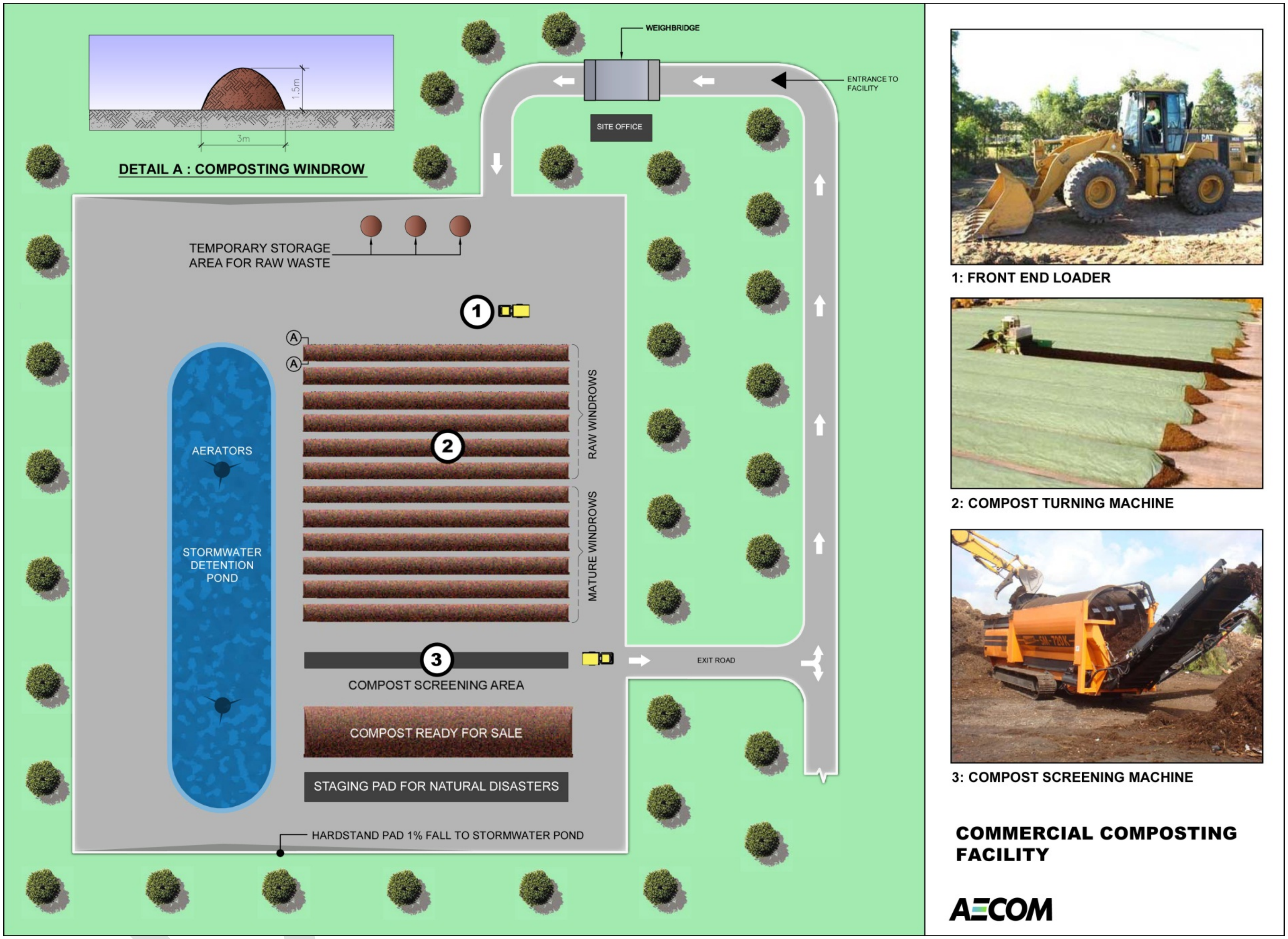

Figure 4: Conceptual Layout of Composting Facility

Table 31: Estimated Capital Costs for Recommended Aerobic Windrow Composting Facility

Item	Cost ($, rounded)
Gravel roads	$35,000
Office	$75,000
Compost pad (compacted clay)	$900,000
Chipper and grinder	$500,000
Loader	$200,000
Storm water detention pond	$20,000
General site development	$50,000
Misc. (fence, seeding, erosion control)	$100,000
Windrow covers (GORE)	$10,000
Contingency	$378,000
Total Capital Costs	**$2,268,000**

4.12.5 O&M Cost Requirements

Operating costs for the proposed aerobic composting facility were previously provided in the Composting Study. These costs have been reviewed and are updated as appropriate in Table 32. The annual operations and maintenance (O&M) costs to operate this facility are estimated to be approximately $350,000. This does not include the potential for revenues from processing fees charged or from the sale of mature compost.

Table 32: Estimated Operating Costs for Recommended Aerobic Windrow Composting Facility

Item		Annual Cost ($, rounded)
Wages	2 site personnel	$60,000
	2 equipment operators	$90,000
	1 weighbridge operator	$70,000
Facility and equipment maintenance		$40,000
Utilities (electricity, water, and sewer)		$40,000
Fuel		$50,000
Total Operating Costs		**$350,000**

4.12.6 Comments

A composting facility is recommended as part of the overall RRP. There may be some synergies and cost savings when considered in conjunction with other RRP infrastructure and site equipment requirements, and possibly the new landfill, as well. Such savings could be investigated, after completion of this Final FS, during the conceptual designs of the landfill and RRP facilities.

4.13 Anaerobic Digestion of Biomass

4.13.1 Description

As an alternative to aerobic composting of organic wastes (Section 4.12), these same materials could be processed using an anaerobic digester. Anaerobic digestion (AD) is the biological conversion of organic materials in the absence of oxygen. The process is carried out by microorganisms that convert carbon-containing compounds to biogas, which consists primarily of methane (CH_4) and carbon dioxide (CO_2), with trace amounts of other gases. For the process to take place efficiently, the following six key process parameters must be carefully controlled: pH, temperature, C:N, organic loading rate, retention time, and reaction mixing.

For municipal solid waste applications, AD focuses on the organic or compostable portions of the waste stream. At present, no commercial gasification units using municipal solid waste as a feedstock are operating in North America. Communities that produce large quantities of organic waste (such as food processing plants) can benefit from AD. It is slowly becoming more common to process large volumes of food or mixed wastes, which are more difficult to control. Anaerobic digestion is significantly more mechanized compared to aerobic composting, and this is reflected in the cost differential. AD relies on engineered vessels or reactors to provide the conditions required to maximize waste decomposition and gas generation. The main benefit of an AD process is the creation of biogas, which can be used to produce energy.

A wide variety of microorganisms are involved in all stages of the AD process. AD can be performed under either mesophilic or thermophilic conditions: mesophilic bacteria operate at an optimum temperature range of 95–104 degrees Fahrenheit (°F), whereas thermophilic bacteria prefer warmer conditions, in the range of 122°–131°F. Actual retention times depend on process design specifics and feedstock characteristics; typical retention times are 12–30 days. Physical mixing of the feedstock is important, as it provides improved contact between the organic material and bacteria, prevents the formation of dead zones and scum layers, and promotes effective heat transfer.

Since AD works only on the organic fraction of the waste stream, pre-treatment processes are typically undertaken to separate the organic fraction from the inorganic and other materials that are unsuitable for treatment in the AD process. The level of pretreatment depends on how the organic material is collected (i.e., in plastic bags or not) and the source. Pre-treatment involves the following processes:

- Removal of non-digestible materials that occupy unnecessary space in the digester
- Provision of a uniform, small particle size in the feedstock to promote efficient digestion
- Protection of the equipment from waste components that may cause physical damage
- Removal of materials that may adversely affect the quality of the digestate

Mechanical pre-treatment is typically accomplished via the following processes:

- Trommel/screens for the removal of the oversized fraction
- A hammer-mill (or similar) for size reduction of the feedstock
- Shredding / mixing of the feedstock (or use of a Hydropulper as a wet pre-treatment process to break-down the organics and separate the heavy metals from the light, non-organic fractions)

Following pre-treatment, the organic fraction is loaded into the reactor, where digestion takes place. During the first stage of digestion, organic material is broken down by microbes called acid-formers to produce fatty acids. During the second stage (generally referred to as methanogenesis), another group of microbes known as methane-producers convert the fatty acids into biogas, which generally contains approximately 55% CH_4 and 45% CO_2, along with various trace gases. The material remaining is a partially stabilized organic material that can be used as a soil amendment or separated into solid and liquid fractions. The liquid fraction can be disposed of in a wastewater plant or used as liquid fertilizer if there are agricultural users nearby. The solid digestate can be dewatered and composted for full stabilization. The insoluble solids in the digestate are composed of non-digestible inert material, non-digestible organic material and microbial biomass. The biogas can be combusted in a generator.

As shown in Table 24, it is estimated that 33,812 TPY of organic material generated in Kaua'i may be captured and processed by the end of the planning period. However, approximately 23,545 tons of this material (or over 74%) is greenwaste. Due to the fibrous nature of this material, it is not suitable for anaerobic digestion. Given the low quantity of feedstock, AD would likely be very ineffective and costly for Kaua'i. Furthermore, Landfill Gas to Energy (Section 4.15) is essentially an anaerobic digestion process for MSW, using the landfill itself as the vessel.

AD technologies are generally divided into categories based on the following:

- The number of digestion stages: single- or two/multiple-stage processes.
- The total solids (TS) content in the process feed: wet process (typically <15% TS) or dry process (typically >15% TS).

4.13.1.1 Single- or Multi-stage Processes

Production of biogas from AD involves a series of biological processes; therefore, moisture is required to sustain biological activity. In single-stage AD systems, these two processes take place in the same reactor while in two-stage AD systems, these processes take place in separate reactors.

The two-stage AD systems can be aerobic-anaerobic or anaerobic-anaerobic. The first process in stage one is the breakdown of proteins, cellulose, lipids and other complex organics into smaller molecules through hydrolysis (the motivation behind wet vs. dry processing). Microorganisms convert the products of the hydrolysis into acids and acetates. These processes are called acidogenesis and acetogenesis. In the second stage, anaerobic microorganisms consume the previously produced acids and acetates for energy, producing methane and carbon dioxide as a by-product.

The advantage to a two-stage digestion process is that the microorganisms in each stage require slightly different environmental conditions (pH levels, primarily) to obtain their optimum performances. Optimizing microorganism performance can lead to faster breakdown of material and/or higher biogas yields. The drawback to two-stage digestion process is the increased technical complexity and substantially higher costs that are not typically supported by higher gas yields from municipal waste.

The majority of AD plants in operation today that process source-separated organics (SSOs) use single-stage (batch or continuous flow) AD systems. The large number of single-stage AD systems is due primarily to the relatively simple design of the system, compared to two-stage systems. Typically, the simplicity leads to lower capital costs for the equipment and less technical issues and failures leading to lower operating costs. As a practical matter, there is generally very little difference in the biogas production performance of single- or two-stage AD systems.

4.13.1.2 Wet or Dry Processes

Typically, SSO have a solid content between 20% and 30%. In wet AD systems, the SSO is diluted to a solid content between 10% and 15% by adding water on a 1:1 basis (265 gallons of water per ton of organic matter). This diluted mixture is pulped to obtain a consistency of a thick soup.

Dry AD systems add water to organic feedstock at a rate of approximately 80 gallons per ton, leaving an organic slurry containing 15–40% solids. The majority of dry AD systems utilize plug flow reactor designs. New material is inserted into one end of the reactor, and the fully digested material comes out the other end.

Typically, some of the digested residue is re-circulated back to the feeding for inoculation to ensure sufficient biological activity and pH balance. An advantage of dry AD systems is that they can handle a wide variety of contaminants (e.g., metal, glass, plastics, wood material). This is a disadvantage at the back end of the process as the end product needs to be handled and processed. These contaminants affect the marketability of the end product.

There is very little difference in the biogas production performance of wet vs. dry AD systems, and very little difference in the capital and operating costs of the actual AD reactors. One of the largest differences between the systems is how the contamination in the organic feedstock is dealt with and the costs associated with this. The produced gas is generally used for three purposes, as below.

- Electricity generation
- Heat generation
- Vehicle fuel

Using biogas to power vehicles has shown to have the lowest carbon footprint, followed by the use of biogas on site in a combined heat and power (CHP) plant.

4.13.2 Space Requirements

The AD facility would require sufficient space for the following.

- Raw waste storage area (should be minimal, as the raw wastes should not stored long enough to putrefy).
- Area for the AD vessel and associated infrastructure.
- Area for curing the finished product.

Assuming that minimal raw waste is stored and that the area for curing is also minimal (if there is a steady end-use for the final product), an area of approximately 3–4 acres would be required.

4.13.3 Benefit (Effective Diversion)

Advantages of AD:

- Targets organic waste stream and is very effective for materials like household kitchen or food wastes.
- Reduce greenhouse gas emissions from landfills.
- Produces green energy.
- Can offset greenhouse gases by providing an alternative to fossil fuels.
- Produces a soil amendment that can reduce fertilizer use.

Disadvantages of AD:

- Targets a small portion of the waste stream (i.e., best for household kitchen or food wastes) but is ineffective for greenwaste, which is the largest volume of organic waste generated in Kauaʻi.
- Has high capital and operating costs.
- May require Government financial support to enable the project to be financially feasible.

4.13.4 Capital Cost Requirements

The cost of AD is affected by economies of scale. Three examples of AD costs are tabulated in Table 33, representing costs for a FS in Sacramento, California (2005), a demonstration facility in Toronto, Canada (2002), and a full-scale facility in Toronto that is currently under construction.

Table 33: AD Cost Examples

Parameter	Toronto (Demonstration Plant)	Toronto (Full Scale)	Sacramento (Study Estimate)
Date	2002	2011	2005
Quantity (tons/year)	25,000	90,000	100,000
Capital Cost ($2011)	$12.5 M	$64.0 M	$38.5 M
Unit Processing Cost	$120 per ton	$97.40 per ton	$72.50 per ton

For Kaua'i, the most comparable cost is the 25,000 TPY demonstration facility in Toronto, Canada. However, only 6,200 tons of non-greenwaste organic materials are expected to be available to the County for processing. The demonstration facility cost $10 million in 2000. In 2011 dollars, this equates to approximately $12.5 million, and corresponds to a capital cost of $500 per annual ton of capacity.

Because this was a demonstration prototype, it did not include equipment for generating any electricity or compressed natural gas. The capital cost of an AD plant with energy recovery is likely to be 40% more. Capital cost for the new full-scale AD plant in Toronto is approximately $710 per annual ton of capacity.

Without large volumes of suitable waste being generated, it is not cost effective to process organic waste through AD, especially when compared to composting, which can manage all types of organic waste (i.e., greenwaste, food waste, biosolids) in varying quantities and in a more cost-effective manner.

Small-scale Alternatives: Other small-scale AD technologies do exist but still require significantly larger quantities of waste than are available in Kaua'i. For completeness, a description of this alternative is provided below. These systems are suitable for the wastes proposed for an AD system and use only approximately 5% of the energy generated for plant operation. They allow the input to remain stationary throughout the process, eliminating moving parts and resulting in low system maintenance and repair costs. The system is closed-loop, whereby the liquid from the digestion process is recirculated.

Small-scale AD technologies are engineered around the concept of holding the feedstock material stationery while using a liquid percolate to move methanogenic microorganisms throughout the material. Input material is piled into an airtight garage-like structure, and, as percolate filters through the pile, digestion occurs. The collected biogas, when combusted in a CHP, produces electricity and heat. Alternatively, the biogas can be processed to natural gas quality and used as fuel. This type of fuel, which contains methane level of more than 90%, can also be used as a vehicle fuel. Biogas can also be burned in a boiler to generate heat.

A range of AD plant sizes with cost estimates are tabulated in Table 34.

Table 34: AD Plant Sizes with Cost Estimated

Amount of Organic Input (tons)	Number of Fermentation Chambers	Biogas Production (million scf)	Installed Electrical Capacity (kW)	Approximate Cost ($ million)
8,000	4	24	220	$2.4
20,000	8	60	550	$6.0
50,000	16	150	1,350	$12.0
70,000	24	210	1,900	$15.0

Note: based on information available from BioFerm Energy.
kW kilowatt

scf standard cubic foot

4.13.5 O&M Cost Requirements

Limited information is available as it relates to O&M costs for an AD facility processing mixed solid waste, since very few such facilities exist. Processing costs on a per-ton basis for three larger-capacity facilities are provided in Table 33. An AD technology provider indicates that annual O&M costs would likely be approximately $650,000 for a facility sized to serve the Kaua'i's waste stream.

4.13.6 Comments

An AD facility is suitable for processing larger volumes of household kitchen or food wastes and mixed organic wastes. Woody and fibrous materials such as greenwaste are generally not appropriate or cost effective for anaerobic digestion. With only an estimated 6,200 TPY of suitable organic material available, this technology is not recommended for inclusion in the RRP.

4.14 BIOREFINERY FACILITY

4.14.1 Description

Hawaii Bioenergy, LLP has initiated a biomass-to-fuel project on Kaua'i referred to as the Hawaii BioFuel Supply Project. It was initially thought that there may be an opportunity to co-locate this bio-refinery at the RRP to achieve savings for the County. In August 2011, the company executed a biofuel supply contract with Hawaiian Electric Company (HECO). The proposed facility must be operational within 60 months following approval of the contract. Within this 60-month timeframe, Hawaii Bioenergy must begin growing appropriate woody biomass crops (i.e., trees), and design, permit, construct, and commission the biorefinery pre-processing facility. As the RRP is not expected to be completed within that timeframe, there is likely not an opportunity to co-locate the facility at the RRP.

Hawaii Bioenergy intends to grow biomass on Kaua'i and process the biomass through a technology such as gasification or AD in order to produce a biofuel and/or generate power. The project will proceed on privately owned lands near the proposed new landfill and RRP. Hawaii Bioenergy may have an interest in receiving and processing all paper wastes that may be available from the County, dependent on the quality of the paper, amount and type of contaminants (e.g., staples), and the market value of the paper. A homogeneous biomass feedstock is preferred for this process, however, and the quantity of paper received from the County would account for only 5–10% of their planned total throughput.

The potential use of biorefinery technologies such as AD or gasification by the County for its own waste stream have previously been considered and identified as not recommended based on a cost/benefit analysis (Section 4.13).

4.14.2 Space Requirements

Hawaii Bioenergy holds a lease on 25 acres of land on a nearby privately held parcel for their industrial facilities, including an area for the cutting, drying, and storage of biomass. If the County were to implement its own biorefinery, a site area of approximately 4 acres would be required.

4.14.3 Benefit (Effective Diversion)

The Hawaii Bioenergy facility is designed to use a woody biomass feedstock. The potential exists to utilize all paper products diverted from the County waste stream. The proposed facility as currently proposed is not designed to process contaminated waste streams or feedstocks with a high moisture content (e.g., food waste, greenwaste). This proposed private facility offers an opportunity for the County to divert approximately 30,000 TPY of waste in the future, or approximately 21% of its waste stream, when considering both residential and commercial sources.

The potential for the County to employ biorefinery technologies in the RRP, such as AD for processing of its waste stream, has been described previously. Based on the heterogeneous nature and limited quantities of the County's waste, these technologies are not recommended for inclusion in the RRP.

4.14.4 Capital Cost Requirements

At present, no commercial gasification units using municipal solid waste as a feedstock are operating in North America. Some demonstration units are operating with the intention to eventually develop full-scale units. These demonstration units have experienced many of the operating difficulties described above when trying to manage municipal solid waste. As a result, no reasonable estimates of capital and operating costs are available.

4.14.5 O&M Cost Requirements

As noted under Capital Cost Requirements (Section 4.14.4), no reasonable estimates of capital and operating costs are available. In the event that Hawaii Bioenergy is interested in utilizing paper from the County's waste stream, the County may receive a fee for this material or incur a nominal cost.

4.14.6 Comments

As described previously, it is premature to recommend that the County include gasification of mixed municipal solid waste, or any other new and emerging technologies, in the RRP.

However, in the event that Hawaii Bioenergy proceeds with the development of their biofuel facility utilizing gasification and would like to supplement their biomass feedstock with paper, the County should pursue this opportunity further.

4.15 LANDFILL GAS TO ENERGY FACILITY

4.15.1 Description

Landfill gas (LFG) is generated by the decomposition of organic material in a municipal solid waste landfill. It is a combustible mixture comprised mainly of methane and carbon dioxide, and is commonly collected and directly combusted to prevent odors, and may optionally be used to generate energy.

The United States Environmental Protection Agency's (EPA's) Landfill Gas Emissions Model (LandGEM) software and other EPA tools were used to estimate the amount of landfill gas (LFG) that the proposed Ma'alo landfill may generate over time (Appendix B). The projected LFG generation rate was used to estimate the amount of LFG-derived energy that may result from landfill operations, and provide the basis of design for the recommended landfill gas to energy (LFGtE) facility. Based on the previously stated project assumptions, the proposed Ma'alo landfill could result in:

- A peak of approximately 1,137 standard cubic feet of LFG per minute (scfm).
- A peak of approximately 3.75 MW of electric-generating capacity,

  or

  A peak of approximately 34 million BTUs per hour (MM BTU/hr) of heat. A total of approximately 14 MM BTU/hr of recoverable waste heat may be available from a 3.75-MW electric-generating system operating at full electric-generating capacity. However, there may be no practical use for this recoverable heat in the vicinity of the landfill.

For a project of this size (approximately 3.75 MW), large reciprocating engines are typically used to generate electric power. The most efficient (in terms of scfm per MW of electric power output) reciprocating engines currently in common use for LFGtE projects have rated capacities of approximately 1.4–1.6 MW. Therefore, approximately three 1.6-MW engine generator sets would be required to utilize the peak LFG production from the proposed landfill. To be conservative (i.e., to maximize financial return on investment by operating the engine/generators at full capacity for as long as possible), a three-engine facility generating a total of approximately 3.75 MW is assumed. Any unused (by the LFGtE facility) LFG collected during the peak years would be flared.

It is essential to understand that, due to the projected site life of the proposed landfill (approximately 264 years), the full 3.75-MW electric-generating capacity would not be available for quite some time. However, one advantage of multiple-engine projects of this type is that generating capacity can be added modularly in 1.3–1.6 MW increments as enough LFG becomes available. A projected 264-year site life means that one of the three planned engine generators could be brought on line in about the 7th year of landfill operation, a second engine generator could be added in about the 18th year of landfill operation, and the third engine generator could be added in about the 97th year of landfill operation. During the landfill post-closure period (after waste has ceased being accepted), the three generators could be similarly phased out, as the landfill gas generation decreases.

4.15.2 Space Requirements

A "typical" three-engine, 3.75-MW LFGtE facility can be housed in a 4,900-ft^2 building on approximately 1 acre of land.

If the County decides to proceed with a LFGtE facility, the recommended system would consist of a building on site with the space to accommodate the addition of reciprocating engines/generators as more waste is landfilled and gas is generated. It is estimated that a 3-engine facility would be required over time. Additional equipment supporting the energy generation would be contained within the building. A connection to the electrical grid would also be required. This facility, including supporting facilities, would occupy approximately 1.5 acres.

4.15.3 Benefit

A LFGtE energy facility can provide the County with a number of benefits. It provides an opportunity to manage landfill gas in a sustainable manner while providing electricity for up to approximately 2,200 homes and revenue potential of up to $6.96 million annually in future years. This facility is recommended for inclusion as part of the RRP.

If a 3.75-MW LFGtE project was implemented at the proposed landfill, it would provide a reduction in emissions equivalent to approximately 158,000 metric tons of carbon dioxide per year, and would generate enough electric power for about 2,200 "typical" homes.

Revenue generation from the sale of electrical energy, at a rate of $0.13/kW-hr (the resale rate quoted in the ISWMP), is estimated to be $1.73 million annually for the initial phase (1.6 MW) and increase to $4.0 million annually when operating at the ultimate capacity (3.75 MW).

LFGtE does not assist in achieving any level of waste diversion. In fact, other efforts to divert the organic waste stream from the landfill would decrease the amount of energy produced at the LFGtE facility. This effect is moderated somewhat by the ability to specify a modular LFGtE system.

4.15.4 Capital Cost Requirements

Capital costs to construct this facility would be approximately $2.32 million for the first phase, increasing to a total of $6.96 million for full capacity build-out.

Similar systems have cost between $1,000 and $1,900/kW, depending on the size of the project, the type of equipment used, and the manner in which capacity is phased in. At an average of $1,450/kW, the first phase (1.5 MW of generating capacity) would cost approximately $2,320,000, and the ultimate capacity (about 3.75 MW) would cost approximately $6,960,000.

These capital costs include reciprocating engine/generators, fuel gas (LFG) compression and free liquid removal, condensate management equipment, brick-clad concrete block building, HVAC (heating, ventilation, and air conditioning), fire detection/alarm system, lubricant and coolant supply and waste holding systems, exhaust silencers, crankcase breather particulate removal equipment, coolant and oil radiators, electrical controls, step-up transformer, step-down transformer, utility interconnect, grounding, sanitary facilities for operator, a very small office/records storage space, and site work (grading/drainage).

4.15.5 O&M Cost Requirements

O&M costs to operate this facility would be approximately $133,000/yr for the initial phase, increasing to $312,000/yr when operating at full capacity.

Operation and maintenance costs (not including fuel cost, debt retirement, or site lease/purchase cost) on the LFGtE facility (not the LFG collection system) are between $0.005 to $0.015/kW-hr of electrical output. At an average of about $0.01/kW-hr, the initial phase (about 1.6 MW of generating capacity) would require about $133,000/yr of O&M, and the ultimate capacity (about 3.75 MW) would require about $312,000/yr of O&M (both assuming about 95% on-line time).

4.15.6 Comments

A LFGtE facility is recommended as part of the overall RRP. While not providing any actual waste diversion, a LFGtE facility does offer a number of substantial benefits. The methane gas generated by the landfilling of waste can be collected and combusted in a manner that enables the production of electricity. Based on the estimated disposal capacity of the new landfill, a LFGtE facility is expected to manage landfill gas in a sustainable manner while providing electricity for up to 2,200 homes and revenue potential of up to $4.0 million annually in future years. By collecting and combusting the landfill gas in a controlled manner, the quantity of greenhouse gas emissions from the landfill would also be significantly reduced.

4.16 WASTE TO ENERGY FACILITY

4.16.1 Description

Waste to Energy (WtE) is a form of energy recovery whereby energy is created in the form of electricity or heat from the direct incineration of waste. Modern incinerators are able to reduce the volume of the waste feedstock by up to 95%, depending on the composition of the waste and the degree of recovery of materials such as metals from the ash for recycling. Various thermal technologies exist that can be used by a WtE facility, including starved air (or multi-stage combustion), mass burn (or single stage combustion), fluidized bed, and rotary kiln. These technologies have been used extensively in North America and Europe over the past 50 years to treat municipal solid waste. The differences between the technologies are technical in nature relating to items such as process oxygen concentrations and temperatures. The outcome is essentially the same, and the choice of a specific combustion unit is not material to the RRP. Technology selection is best left to the technology vendor that can specify the appropriate unit based on the expected waste quantities and composition available.

Mass burn facilities are often chosen for their relatively simple operation and reliability, and their ability to process a highly variable mixed waste stream. As a result, mass burn is currently the industry standard for WtE, accounting for the majority of WtE plants in Europe and the U.S. Most WtE facilities are modular, consisting of more than one combustion unit with the ability to add additional units. The average size of these WtE facilities is in the order of 200,000 tons per year in Europe and closer to 300,000 tons per year in the U.S. The U.S. EPA reported that in 2010, a total of 86 WtE facilities were operating in the country.

Residual waste that is not treated through the WtE facility, as well as the combustion ash, would be deposited into the landfill. Based on O'ahu's experience, the DOH may require the County to operate a monofill portion of the landfill to manage the ash separately from the other MSW.

The reliability of a power plant is intrinsically linked to the quality of the feedstock. Understanding the characteristics of waste streams generated on the island, which will ultimately be the feedstock to the plant, inform the basis of the design and processes for the plant in terms of power generation (steam production), flue gas treatment requirements, and residue production for the effective long-term operation of a facility.

In order to invest in a WtE facility, a comprehensive fuel supply (waste composition) study should be undertaken involving a study to estimate the quality and volume of waste available as fuel for the WtE facility. With a high degree of confidence, the calorific value, moisture content, chemical composition, environmental health hazards, waste composition, ash content and other relevant information should be gathered. The conceptual design of the plant would be developed based on the information obtained during the fuel supply study. An economic analysis can then be undertaken, where an in-house financial model is developed for the purpose of computing estimated tariffs, debt capacity, expected profitability, investor return, and other financial parameters, by providing technical and cost assumptions. This information would be used as the basis for deciding if WtE is the most suitable method of managing certain waste streams on the island.

Notwithstanding the need for an in-depth study to more accurately determine the feasibility of a WtE facility, the following information provides an overview of important considerations for a WtE facility and provides initial, planning-level cost estimates. A process description for a WtE plant is discussed, followed by waste composition data, the energy potential for the waste proposed for the plant, and the likely capital and operating costs for the facility.

The processes involved in, and characteristics of, a WtE facility are listed below, and are described in detail in the following subsections:

- Waste input and throughput
- Waste receipt, handling, and storage
- Grate and boiler
- Steam / condensate / power generation
- Water management and demineralization water production
- Flue gas treatment
- Residue handling – bottom ash and flue gas treatment

Waste Input and Throughput. The design of a WtE plant is based on the optimum waste throughput and corresponding calorific value of the waste streams. WtE plants are typically designed for 7,800–8,000 hours per year of operation.

The firing diagram (which would be developed based on the fuel supply study; an example is provided in Figure 5) informs the design of the thermal technology that would be implemented on the island. The heat and mass balance would be developed and optimized to maximize electrical production.

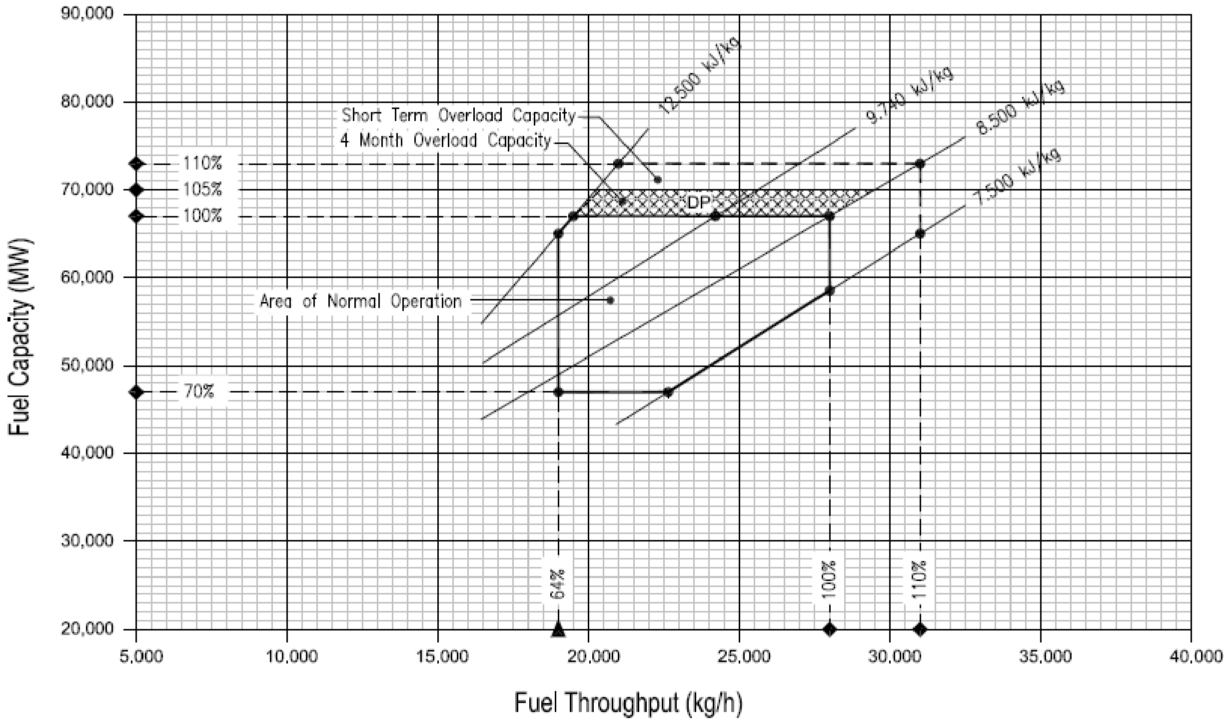

Figure 5: Example Firing Diagram

Waste Receipt, Handling, and Storage. Some of the integral components of a WtE plant are the areas for waste receipt including truck movements, waste handling and the storage requirements. The waste receipt requirements include facility and information management such as weighing waste loads prior to tipping at the WtE plant. At a minimum, barriers/gates, security systems and weighbridge facilities need to be provided (and could possibly be shared with the landfill for cost savings). The reception hall and waste bunker arrangement should be sized based on anticipated vehicle movements and the size/type of vehicles.

The bunker needs to be sized to provide sufficient storage to manage short plant outages, allow continuous plant running when waste is not delivered (e.g., over weekends), and provide a general buffer for the storage of waste. Bunker storage is typically provided for 1–2 days of waste input at WtE plants. The purpose of the bunker is to act as a buffer between truck deliveries of fuel and fuel input into the grate. The bunker also enables the crane system to mix the waste prior to feeding the chute and the grate. For this reason, it is important that waste is fed into the plant consistently, particularly in terms of the calorific value and composition characteristics. Mixing and feed crane movements therefore require careful planning.

Other considerations include pre-treatment requirements, such as pre-shredding of bulky wastes prior to the waste being deposited into the waste bunker.

Grate and Boiler. The grate and boiler are typically integrated systems. There are variations in grate types, and these are normally based on the different modes of grate movement, such as forward reciprocating, reverse reciprocating and roller systems. The time and temperature profile through the boiler needs to be considered in terms of energy transfer and also pollutant formation, particularly dioxin formation due to de-novo synthesis. Other considerations include boiler cleaning to reduce fouling and ensure good heat transfer.

Steam / Condensate / Power Generation. The efficient operation of the steam turbine generator system is one of the key elements of the commercial viability of the project. Specifically, an optimized process design between the condenser and turbine exhaust, and the individual process units is essential. Other efficiency-enhancing systems (e.g., the use of waste heat to provide energy for an absorption chiller) to enhance the overall system efficiency and optimize capital / operating costs are options for a WtE facility.

Water Management. One of the key considerations for a WtE facility is the management of water within the plant. Water is used in WtE facilities for the following purposes:

- Make demineralized water for feeding to the boiler.
- Make demineralized water for other facility uses such as dilution water for de-NOx (nitrogen oxide removal) or waste chute cooling water.
- Provide boiler cleaning requirements (either waste sprays cleaning or steam soot blowing).
- Provide ash quench water. Normally wastewater from process activities (e.g., boiler blow-down and demineralization regeneration water) is used for the majority of the quenching requirements, but this is often topped-up using raw water when necessary.

In order to understand the water usage requirements for a WtE facility, an outline water balance and water quality assessment should be undertaken. This would include the process, fire management, and sanitation / welfare requirements.

Flue Gas Treatment. The pollutant levels in the flue gas for a proposed WtE facility need to be considered. The initial assessment would be used for the design of the flue gas treatment system. The pollutant levels can be estimated using knowledge of the waste input to the WtE plant. Flue gas treatment is fundamentally important for any WtE plant, given the tightly controlled and managed air emissions standards in the United States.

Residue Handling. For a WtE plant, two residue streams require handling: bottom ash and flue gas treatment residues. Bottom ash disposal is dependent on its quality, and the quality is dependent on the combustion technology used as well as the design and operating parameters.

4.16.1.1 WASTE COMPOSITION

As stated above, in order to invest in a WtE facility, parameters such as the calorific value, moisture content, chemical composition, and environmental health hazards would need to be determined through further study. This information can be determined by calculations based on the waste composition. Table 35 provides an estimate of residual wastes available for a WtE plant during the 20-year planning period. The estimates consider the projected diversion achieved through management of recyclables and organic (i.e., greenwaste) wastes.

Table 35: Composition of County Municipal Waste, Projected for 2017–2037

Year	Waste Type								Total Waste Generated (TPY)
	Captured Residential Recyclables		Captured Organics (Commercial + Residential)		Captured Commercial Recyclables		Residual for WtE Plant		
	TPY	%	TPY	%	TPY	%	TPY	%	
2017	7,682	7%	23,285	20%	9,481	8%	74,375	65%	114,905
2027	9,504	7%	30,482	23%	15,890	12%	74,564	57%	130,439
2037	12,418	8%	33,812	23%	23,775	16%	79,286	53%	149,291

Notes: Residential Recyclables from Table 13 (with recovery expected to vary from the low to high estimate over the planning period).
Captured Organics (Commercial + Residential) from Table 24.
Captured Commercial Recyclables from Table 16.

Total Waste Quantity Generated from Table 8.
Residual for WtE Plant is the Total Quantity minus the other Quantities listed.

4.16.1.2 ENERGY POTENTIAL

The calorific value is a term used for WtE plants and is known as the quantity of heat produced by the complete combustion of a given mass of a fuel. Each waste (feedstock) used in the WtE facility has a different calorific value and therefore a differing capability of producing energy. Table 36 provides data on the calorific values for a variety of wastes.

Table 36: Average Calorific Values

Waste Type	Subcategory	Calorific Value (MJ/kg)
Paper	Newspapers	18.55
	Magazines	17.07
	Other paper	15.75
	Liquid cartons	26.35
	Card packaging	16.38
	Other card	16.38
Plastic	Bags and film	41.50
	Bottles	22.00
	Food packaging	38.00
	PVC	22.59
	Other dense plastic	40.32
Textiles	Textiles	16.12
Miscellaneous Combustibles	Disposable nappies	4.00
	Other	20.14
Putrescible	Dry garden waste	18.49
	Wet putrescible	4.17
Fines	10-mm combustibles	14.79
	10-mm non-combustibles	0
Glass		0
Metal		0
Other non-combustibles		0

MJ/kg megajoule per kilogram
mm millimeter

Of the total waste forecast to be generated for each year (tabulated above), the residual that would be used as feedstock for the WtE plant was estimated, as shown in Table 35. The calculations below are based on 2037 data. For ease of reference, the quantity of waste has been rounded to 80,000 TPY in the event that waste generation is greater than projected or that it takes longer to achieve the projected levels of waste diversion. It is noted that the ISWMP considered a WtE facility of only 40,500 tons to accommodate the residential waste stream only.

The energy generation potential can be estimated using the following calculations. Using the design value of 80,000 TPY of waste, and assuming that the plant will operate for 7,900 hours per year (hr/yr) (WtE plants typically operate 7,800–8,000 hr/yr), then the throughput of waste is 10.13 tons per hour, or 2.81 kilograms per second (kg/sec).

By comparison, on O'ahu, H-POWER reportedly processes over 600,000 tons of waste annually, producing 7% of O'ahu's electricity (http://www.opala.org/solid_waste/archive/How_our_City_ manages_our_waste.html).

The net calorific value can be obtained by using the calorific values of each of the wastes proposed to be treated in the WtE facility and the likely energy that can be generated can be calculated based on the net calorific value (CV). More specifically, residual waste can be approximated to have a CV of 9–10 megajoules per kilogram (MJ/kg). Using 9.5 × 2.81 kg/sec = 26.72 MJ/second (megawatts [MW]). The efficiency of a WtE plant will depend on the design; however, it can be assumed that the facility will operate with an efficiency of 25% net energy generated and 28% gross energy (typical for a facility with steam production at 60 bar, operating at 400 degrees centigrade [°C]). A full heat balance is needed to understand this with accuracy; however, 25% can be used for the purpose of providing an approximate energy generation figure. As such, 26.72 MJ/sec (MW) × 25% = 6.68 MW/second × 7,900 hours per year = 52,780 MW-hours per year (net value) of energy generated.

4.16.2 Space Requirements

An 80,000-TPY WtE facility, including supporting facilities, would occupy approximately 6–8 acres.

4.16.3 Benefit (Effective Diversion)

A WtE facility could process up to 80,000 TPY (i.e., 53% of the County's waste stream) by the end of the planning period. Allowing for 25% non-combustible waste, 60,000 tons of waste could be diverted from landfill.

4.16.4 Capital Cost Requirements

For a WtE facility accepting approximately 80,000 TPY of waste, the capital costs are likely to be $120–$125 million. For a WtE facility accepting 100,000 TPY of waste, the capital costs are estimated to increase to approximately $150 million. For a greater quantity of waste, the capital costs do not increase significantly. The capital costs for smaller facilities are often equally as expensive as medium-sized WtE facilities. The County could obtain a more complete estimate of capital costs through a request for proposal process, in which potential vendors can provide their costs based on a technology and design best suited to manage the available waste stream.

4.16.5 O&M Cost Requirements

Operating costs for a WtE facility include the following:

- Labor costs
- Chemical costs
- Residues handling costs
- Maintenance and consumable costs, e.g., water usage

The likely operational costs are detailed below.

Labor Costs. Generally, WtE labor staff work on a shift system, whereby there are rotating shifts of people working 12 hours per day. For a facility with a throughput of 80,000 TPY, approximately six groups of 2–3 workers would rotate throughout the week. As a result, approximately 12–18 operating staff would be required.

A maintenance team would also be required. Generally, the maintenance team does not work on a shift basis; instead, they work on an on-call basis. The maintenance team would consist of a mechanical fitter, electrical technician, a manager of instrumentation, and a control engineer.

In addition, a day crew is required for tasks such as operating the weighbridge and managing chemical deliveries. The day crew would generally consist of 2–3 people. Savings may be realized in synergy with other RRP requirements.

The management team for a WtE facility treating 80,000 TPY of waste would generally consist of a plant manager and an O&M manager. In addition, a person would be designated in a compliance role. This person would ensure that the facility is being operated in accordance with the regulatory requirements, conduct audits as necessary, liaise with EPA and DOH, and manage data generated through monitoring at the facility. This person would generally have an Environment, Health and Safety background.

The total number of staff required for an 80,000-TPY facility would be approximately 20 full-time staff, with additional support staff on an as-needed basis.

Chemical Costs. Various chemicals are required for the operation of a WtE facility, including lime, powdered activated carbon, and ammonia. Annual chemical costs are estimated to be approximately $500,000–$750,000.

Residue Handling Costs. Fly ash and flue gas treatment residues can contain high quantities of heavy metals and require effective management to protect the environment and public health. These residues require treatment before being disposed of at a hazardous waste landfill. For a 80,000 TPY WtE facility, approximately 3.5% of the waste for treatment will end up as residues (when using a dry lime system). As such, 2,800 TPY of residues would be generated, requiring effective management, likely monofill landfilling. Assuming a cost of $200 per ton of waste for disposal, this cost would total $560,000 annually.

Bottom ash is also generated in a WtE facility. Assuming 25% of the waste by weight is non-combustible, up to 20,000 TPY of bottom ash may be generated. Bottom ash can be beneficially recycled by using it as road base or for a number of other uses. If no beneficial use is found, then the ash must be landfilled.

Maintenance and Consumable Costs. Another cost that needs to be considered is the cost of maintenance and consumables, including the cost of water used in facility. These costs should be explored more thoroughly upon executing an in-depth FS for investing in a WtE facility on the island.

Based on published data for operating WtE facilities, annual operating and maintenance costs plus residual disposal are estimated to total $7–$10 million for an 80,000-TPY facility. This does not include annual capital charges. These annual costs are offset by revenues received from tipping fees, metal recovery and sales, plus energy (estimated 53,000 MW-hours per year). Revenues from energy are estimated to be up to approximately $7 million per year.

When factoring these annual costs and revenues together, the total cost per ton is expected to exceed $110–$120 per ton.

For comparative purposes, the ISWMP developed costs for a WtE facility based on a throughput of 40,500 TPY, or less than half of the residuals available on the island. The ISWMP estimated capital costs of $46–$52 million and annual operating costs of $8–$9 million including debt service. The cost per ton, net of energy revenue, was estimated to be $121–$139 per ton.

4.16.6 Comments

A WtE facility is not recommended at this time as part of the overall RRP. Assuming that the County continues with its waste diversion initiatives, a WtE facility could process up to 80,000 TPY (i.e., 53% of the County's waste stream) by the end of the planning period. Allowing for 25% non-combustible waste, 60,000 tons of waste could be diverted from landfill. A WtE facility, including supporting facilities, would occupy approximately 6–8 acres. However, capital costs to construct this facility would be up to approximately $150 million, and O&M costs to operate this facility would be approximately $120 per ton, net of energy revenues, and not including landfilling of residuals. The WtE facility could extend the expected life of the new landfill by approximately a factor of 4. WtE is a very expensive technology, requiring significant up-front capital costs, and carrying a significant financial risk if the waste feedstock decreases and the facility does not run at capacity.

4.17 WASTE TO FUEL FACILITY

4.17.1 Description

Waste-to-fuel systems involve the processing of MSW to produce a fuel and subsequent use of that fuel as a substitute for some of the fossil fuels in utility power generation, typically including industrial, commercial, or institutional applications (e.g., power generation or water heating). Two such waste-to-fuel systems include:

- Any one of numerous proprietary processes to produce a refuse-derived fuel (RDF), the final stage of which may include the densification of the RDF into pellets (Section 4.17.1.1).
- Gasification or pyrolysis, which produce a synthetic gas ("syngas") (Section 4.17.1.2).

In either case, given the heterogeneous nature of MSW, some form of up-front processing is required to improve the combustion characteristics of the fuel. In the case of the production of an RDF, various levels of pre-processing are possible, but they all involve the same basic operations. Non-combustibles are removed from the waste in order to reduce the quantity of ash and to increase the heating value of the waste introduced into the facility. Further, removing certain materials containing higher concentrations of heavy metals and trace organics improves the effectiveness of the air pollution control systems employed post-combustion. Recyclable materials may also be captured, and organic matter may be removed for subsequent management via composting or anaerobic digestion. Alternatively, moisture from the organic fraction of the incoming waste stream may be driven off to render the organic material more suitable as a fuel (by making it drier).

4.17.1.1 RDF PROCESSING

RDF refers to fuel in any form that is derived from waste. The term RDF is commonly used to refer to solid waste that has been mechanically processed to produce a readily storable and transportable fuel that is homogeneous, and thus optimized for combustion. RDF processing has two basic components: RDF production and RDF incineration. An RDF production facility makes RDF in various forms through materials separation, size reduction, and pelletizing. Although RDF processing has the advantage of removing recyclables and contaminants from the combustion stream, the complexity of this processing has increased the operating and maintenance cost and reduced the reliability of RDF production facilities. On average, capital and operating costs per ton of capacity for incineration units that use RDF are higher than for other incineration options.

A significant number of proven proprietary RDF processes are currently available in the marketplace. In general, most include the following fundamental component processes:

- Initial floor sort off the tip floor for the initial removal of large oversized materials and other non-processable materials
- Shredding (using slow speed shredders)/screening (using multiple-stage trommel screens) to size classify and facilitate downstream secondary processes
- Initial magnetic separation for the removal of bulk ferrous materials
- Density segregation into heavy, mid-heavy and light fractions (heavy and mid heavy objects are removed from the waste stream and inspected for consumer electronics, ferrous and non-ferrous metals and polyvinyl chlorides (PVCs) using overhead belt magnets, eddy current separators, optical sorting equipment)

- Secondary shredding
- Further removal of ferrous and non-ferrous metals by magnetic separation and eddy current separation
- Separation of dry materials by air classification and sieving processes
- Drying
- Where the point of combustion (final usage of the RDF as an alternate fuel) is remote from the RDF production plant and the cost of transportation to the combustion facility is significant, it may be necessary to reduce the transportation costs by densifying the loose RDF to increase transportation payloads. In this case, the loose fluffy RDF is fed into a machine that compresses and forces it through a series of rotating dies and produces a pelletized product as shown in Figure 6.

Figure 6: Typical RDF Pellets

A number of RDF facilities were constructed in Europe in the 1970s and 1980s, mostly of German and Italian design. The RDF produced is usually in the form of either pellets or baled paper and plastic, which have been marketed for use in electrical generating stations that use fluidized-bed technologies. RDF is typically only produced in situations where markets are remote from the point of generation and the material requires long-distance transport. Appendix C presents a case study of an RDF facility recently brought into operation in the Toronto, Canada area. That facility experienced difficulties in producing a product with sufficient energy content that would support using it as a replacement fuel source. Consequently, other high-BTU-value materials have been combined with the municipal waste to produce a better product. The marketability of the product has been affected by the low heating value of the pellets.

4.17.1.2 GASIFICATION/PYROLYSIS

Gasification is the general term used to describe the process of partial combustion in which a fuel is combusted with a quantity of air deliberately set below the stoichiometric amount required for complete combustion. This process produces a combustible synthetic gas (syngas) that can fuel an internal-combustion engine, gas turbine, or boiler, under excess-air conditions. Such systems can be used to convert municipal solid waste into a gaseous fuel.

Gasifiers have been used since the 19th century for coal and wood. By the early 1900s, gasifier technology had been advance and was used on certain industrial waste streams to produce 'synthetic' natural gas fuel for stationary and portable internal combustion engines. Gasoline shortages of World War II provided the impetus for the development of gasifier technology; however, with the return of relatively cheap and plentiful gasoline and diesel fuels after the end of the war, gasifier technology was all but forgotten.

Gasification involves the thermal breakdown of solid waste materials into a gaseous constituent (syngas), and a solid char residue. The process is endothermic i.e., requires external energy. This process energy is either provided by allowing a very limited amount of volatiles in the feedstock to combust in a reactor (gasifier).

Before gasification can occur, solid waste is generally subjected to some pre-processing. Depending on individual thermal process requirements, this can range from coarse shredding, drying, recyclable material recovery and mechanical sorting to produce a homogeneous feedstock.

All components of typical municipal solid waste can be fed into the system, but only the volatile fraction of the waste (for example food waste and yard waste, paper fibers, sanitary products, plastics, and wood) would be used. Since gasifiers can process all but inert material, gasification is technically well suited for the processing of post-diversion residuals feedstock. As it relates to municipal solid waste, gasification is considered a new or emerging technology. It is best suited to homogeneous feedstock, compared to the heterogeneous nature of municipal waste.

Syngas consists primarily of carbon monoxide, hydrogen, CO_2, and nitrogen and typically has a heating value of approximately one-third of natural gas. Syngas must generally be subjected to a cleaning process before it is used for the generation of heat. After cleaning, syngas can be used as fuel for reciprocating engines or gas turbines, or it can be combusted in a steam boiler to generate steam under utility conditions, the same way natural gas is used.

The solid residue existing after gasification is generally inert. Portions of it can be recycled (metals), but the majority of this material typically requires landfilling.

Currently, there is limited operating experience of gasification technology for mixed solid waste, primarily in Japan and Europe. However, there are plans for construction of a commercial facility in Edmonton, Canada to process compost residues with high plastics content.

Pyrolysis is similar to gasification with the exception of the heat source. A pyrolysis system uses an external source of heat to drive the process whereas gasification uses the heat from the waste. Typically gasification is configured to maximize the production of gaseous fuel and pyrolysis is optimized to produce liquid fuel. There is only limited operating experience with pyrolysis technology for mixed solid waste, primarily in Japan.

Plasma arc gasification is also being investigated for management of solid waste. The technology is commonly applied for industrial applications like the electric arc furnace in the steel industry and arc welding units. Plasma arc relies on extremely high temperatures in an oxygen-starved environment to gasify waste. It is similar to a conventional gasification system where the heat is supplied by a high temperature plasma field. This technology has been applied on a limited basis in Japan. A plasma gasification facility has also been undergoing demonstration in Ottawa, Canada.

Some select case studies are presented in Appendix G. Generally, the information available for existing facilities indicate that there would be significant risk in relying on these technologies to manage Kaua'i's MSW, and we do not currently recommend it as a reliable and effective solution.

4.17.2 Space Requirements

A site area of approximately 3–4 acres would be required to support a waste-to-fuel facility including supporting infrastructure.

4.17.3 Benefit (Effective Diversion)

Based on the waste composition and projection in Sections 3.3 and 3.4, it is estimated that following diversion of residential and commercial recyclables plus organic wastes and non-curbside collected materials (e.g., HHW, tires, scrap metal, electronics, residential C&D material), approximately 55% of the total waste stream may be available as feedstock for a thermal process. This represents approximately 77,600 TPY at the end of the 20-year planning period (i.e., 148,000 tons – 12,418 tons – 14,265 tons – 33,812 tons – 9,900 tons). It is typical to assume that approximately 25% of the waste stream by weight is non-combustible and requires further management as a residual (i.e., typically the landfilling of leftover ash, as is done on O'ahu). Therefore, overall diversion at a waste-to-fuel plant could be approximately 41% of the total waste stream.

Gasification/Pyrolysis: Gasification and pyrolysis can produce a combustible synthetic gas (syngas) that can fuel an internal-combustion engine, gas turbine, or boiler. The gas can be transported by various means to be used as a fuel source at another location. In addition, the high-temperature process can be used to vitrify the ash residue, making it suitable for alternative uses and not requiring that it be landfilled.

RDF Processing: RDF is typically only produced in situations where markets are remote from the point of generation and the material requires long-distance transport.

4.17.4 Capital Cost Requirements

Gasification/Pyrolysis: At the present time, there are no commercial gasification units operating in North America using municipal solid waste as a feedstock. There are some demonstration units with the intention to eventually develop full-scale units. These demonstration units have experienced many of the operating difficulties described above when trying to manage municipal solid waste. As a result, no reasonable estimates of capital and operating costs are available.

RDF Processing: The capital costs of the Toronto-area private RDF facility highlighted in Appendix C, with a capacity of 75,000 TPY, were approximately $50 million.

4.17.5 O&M Cost Requirements

Gasification/Pyrolysis: As noted under Capital Cost Requirements (Section 4.17.4), no reasonable estimates of capital and operating costs are available.

RDF Processing: The Toronto-area private RDF facility highlighted in Appendix C charges $88 per ton for processing municipal waste into pellets. Their actual costs are not known. A market for the RDF pellets must then be found by the contractor. The main driver for this facility is the lack of local and affordable landfill disposal capacity.

4.17.6 Comments

Gasification/Pyrolysis: It is premature to recommend gasification of mixed municipal solid waste, or any other new and emerging technologies, for inclusion in the RRP.

RDF Processing: Given the lack of markets for a RDF product in Kaua'i suitable for combusting a waste material, the short distance to potential fuel substitute markets if they exist, the fact that RDF production does not achieve waste diversion unless there is a market for the RDF product, and the incremental cost for waste management, this is not a recommended component of the RRP.

5.0 POTENTIAL ENVIRONMENTAL IMPACTS

The following is a consolidated list of potential facilities for the RRP, as described in Section 4:

1. Integrated Public Drop-off and Reuse Facility
2. Recyclables and Waste Drop-off
3. Household Hazardous Waste Depot
4. Electronic Waste Depot
5. Metals Recycling Facility
6. Construction and Demolition Material Processing and Recycling Facility
7. Used Tire Processing Facility
8. Center for Hard-to-Recycle Materials
9. Reuse Center
10. Educational Center
11. Materials Recovery Facility
12. Composting Facility
13. Anaerobic Digestion of Biomass
14. Biorefinery Facility
15. Landfill Gas to Energy Facility
16. Waste to Energy Facility
17. Waste to Fuel Facility

The construction and operation of these facilities has the potential to cause impacts to the environment through emissions to the air (noise, particulates, odor), water, and soil environments, plus nuisance impacts associated with vehicle traffic. When one or more program or technology is selected for the RRP, all potential impacts should be mitigated to the greatest extent practicable, and this can be achieved through efficient and responsible design, construction, and operational techniques. The potential impact mitigation measures will be detailed in an environmental impact statement (EIS), subsequent to this FS. For now, in order to better understand the potential impacts associated with each proposed activity that will need to be considered and mitigated, and to ensure that the EIS analyzes the full range of possible impacts, a summary of the potential environmental impacts is provided below.

The activities undertaken at the integrated or centralized public drop-off and reuse center would be largely outdoors. The exception would be the reuse activities, educational facilities, HI-5 redemption center, and HHW facilities, which would be in an enclosed building. The drop-off area would be on a paved surface or pad with proper site drainage for storm water collection and management, and minimizing potential effects to groundwater. It is proposed that a roof or canopy be in place over the various drop-off bins to protect the materials from inclement weather and minimize any potential contamination. The main source of air emissions would be associated with public vehicle traffic and that of onsite traffic when moving the collection bins. Only a small amount of putrescible waste is expected to be collected at this location, so the potential for odors would be minimal.

The MRF would be inside an enclosed building, preventing contact of waste with any storm water. Impacts to land or groundwater are also likely to be negligible, assuming that the facilities are operated on an impervious floor surface within an enclosed building. Operating within an enclosed building would minimize air impacts (noise and/or particulates), and no putrescible waste would be managed through this facility. Curbside collection truck traffic delivering collected materials to the facility may create traffic impacts on local roads, and have associated noise and particulate impacts. Any wastewater would be collected in the building's drainage systems and properly managed.

The aerobic processing of organics may cause environmental nuisance through air emissions (odor or particulates). Noise impacts may be associated with site equipment used to turn the compost piles. Impacts to storm water may occur through contact with waste, and site runoff may require management as leachate. Potential impacts on groundwater from waste leachate may be mitigated by operating on a paved or impervious surface. If the RRP is collocated at the landfill, then storm water and leachate management facilities would be readily available. Truck traffic to the facility may generate nuisance traffic impacts on local roads and have associated noise and particulate impacts. These impacts can be mitigated through an effective design for the facility and responsible day-to-day operation.

The operation of an anaerobic digestion facility could impact the air environment through potential odor emissions. No potential for waste contact with storm water or groundwater is anticipated. Truck traffic to the facility may generate nuisance traffic impacts on local roads and have associated noise and particulate impacts.

The metals, C&D material, used-tire, and hard-to-recycle materials processing would be conducted on a hard surface pad. Runoff would be controlled on site with proper drainage for storm water collection and management. The paved surface would minimize any potential for contact with groundwater. The grinding, crushing, and shredding of materials has the potential to create air emissions including dust/particulates and noise. Dust and noise emissions may also result from mobile equipment and truck traffic.

Due to the nature of activities undertaken at waste-to-energy and waste-to-fuel (gasification and RDF) facilities, numerous wastes including bottom & fly ash, as well as flue gas air emissions, are generated. Although it is not possible to prevent generating these wastes, the EPA has regulations that ensure the responsible disposal of solid wastes. Similarly, flue gas treatment systems would be included to ensure that air emissions are minimal, in accordance with the EPA regulations. No potential for waste contact with storm water or groundwater is anticipated. Truck traffic to the facility may generate nuisance traffic impacts on local roads and have associated noise and particulate impacts.

The environmental impacts of LFGtE activities are associated with air emissions from a combustion engine and odor emissions; they should, however, be compared to the landfill gas emissions that would occur in the absence of a LFGtE facility.

A biorefinery facility would utilize gasification and/or anaerobic digestion technology and include enclosed buildings and potentially a series of tanks located outside. No potential for waste contact with storm water or groundwater would be anticipated. Potential impacts from this type of facility could include air emissions and odor. Truck traffic to the facility may generate nuisance traffic impacts on local roads and have associated noise and particulate impacts.

Projected vehicle traffic generation for the various proposed components/facilities is presented in Appendix D.

6.0 SUMMARY AND RECOMMENDATIONS

Table 38 summarizes the costs and benefits of the potential RRP components and facilities, and makes recommendations for facilities that are considered feasible for implementation at the RRP. A schematic material flow diagram of the potential RRP, based on the feasible facilities, is presented in Figure 7. Once the desired RRP components and facilities are chosen, a site-specific conceptual design, including acreage, will be developed.

The following elements are recommended as feasible for implementation at the RRP, subject to other, non-technical constraints and considerations:

- A centralized drop-off facility that includes drop-off bins for recyclable materials, greenwaste, scrap metal, C&D waste from residents and small commercial generators, used tires, and residential wastes.
- An onsite processing area for metals including vehicles, white goods, propane tanks and scrap, C&D waste, and used tires.
- A specially designed area for the receipt, bulking, lab packing, and storage of household hazardous waste, used motor oil and filters, used cooking oil, electronic waste, a HI-5 redemption area, a reuse center, and center for hard-to-recycle materials.
- A single-stream MRF, designed to process residential curbside-collected materials, HI-5 materials, and materials that may be attracted from commercial sources, including an educational center.
- A composting facility transitioning to an aerated static pile facility to process curbside-collected greenwaste, bio-solids, and food waste.
- A LFGtE facility.

Table 37 provides a summary of estimates of the net revenues per ton of diverted waste over the 20 year planning period (2017 and end of year 2036), for each feasible facility. Additional details, including methodology and assumptions used to calculate these estimates (such as a 2% annual inflation rate over the 20-year study period), are included in Appendix E. As a preliminary estimate, those facilities above the dashed line are expected to cost less than the landfill tipping fee, over the 20-year planning period. Because commodity prices fluctuate significantly, and the diversion rates are subject to a host of factors, these projected revenues should be considered planning-level estimates.

As outlined in the table, the MRF and the LFGtE facilities are the only RRP facilities that are expected to generate positive revenue. The RRP facility that generates the largest loss, in net revenue per ton of waste diverted, is the integrated public drop-off and reuse facility. The net revenues (or cost) shown in Table 37 should not be considered alone when evaluating each RRP component, because these facilities have other benefits such as increasing landfill diversion, improving leachate quality, and promoting the reuse and recycling of materials – benefits that may outweigh their direct individual costs in non-monetary ways.

Note that the landfill gas to energy facility, which does not divert material from the landfill, is estimated to generate positive net revenue ($1.6-$2.4 million per year).

Table 37: RRP Facility Annual Amortized Cost per Ton of Diverted Waste

	Cost ($/ton)	
Facility	**Year 1**	**Year 20**
Materials Recovery Facility	80.24	-77.89
Composting Facility	23.47	21.45
Metals Recycling Facility	27.61	29.70
Waste to Energy Facility	142.88	161.79
C&D Processing and Recycling Facility	115.33	164.08
Used Tire Processing Facility	132.13	188.28
Integrated Public Drop-off and Reuse Facility	237.87	329.39
	Revenue ($MM/year)	
	Year 5	**Year 20**
Landfill Gas to Energy Facility	1.7	2.4

Table 38: Summary of Potential RRP Components/Facilities

Component/Facility	Description	Approximate Acreage Required	Benefits	Capital Cost (Estimated)	Annual O&M Costs (Estimated)	Estimated Diversion and Other Comments
1. Integrated Public Drop-off and Reuse Facility • Includes the RRP components listed in rows 2–9 below.	This essential set of components and facilities are generally recommended to be implemented at any RRP. Wastes that are not collected curbside can be received directly from residents or businesses to provide an outlet for the public to dispose of large-volume or bulky non-hazardous waste materials, and small-volume difficult-to-manage or hazardous waste materials. Many of these components and technologies are already provided in some form on-island. Including these as part of the RRP may offer the opportunity to support and complement the programs already available to residents, and will promote increased diversion due to the convenience of a centralized one-stop service center. Consolidating these facilities may also provide for cost savings, compared to individual operation of all of the existing facilities.	5–10 acres	• Promotes increased reuse, recycling, reduction, sustainability, and diversion from the landfill. • A wide variety of materials can be managed in one location, which promotes economic and logistical efficiency. • These types of facilities are easy to manage and cost-effective to staff, as staff resources can be shared. • Provides a common level of service available to all residents. • Components are well understood as most are currently being utilized by the County. • Highly visible nature of the various onsite activities helps to increase environmental awareness and further educate the public on the opportunities to maximize diversion. • Potential to reduce time and transportation. • Opportunity to promote reuse via the reuse center. • Opportunity for research and increased environmental awareness through educational center. • Removes potential materials of concern from landfill and improves leachate quality.	**$8.9 million**, depending on site-specific design features	**$1.4 million**, consistent with current drop-off and recycling programs offered by the County. By co-locating the components at the RRP, it is anticipated that efficiencies can be gained. Additional savings (not calculated herein) may also be realized by reducing the existing facilities' budgets.	Recommended as key part of the overall RRP as a cost-effective way to consolidate and promote diversion from the landfill. It is estimated that: • Approximately 9,700 TPY of recyclables will initially be managed and diverted at the public drop-off and reuse center (8% of the total waste stream); and approximately 19,000 tons of material may be diverted by the end of the 20-year planning period (13% of the total waste stream). • Approximately 6,900 TPY of other materials not managed through a curbside program (e.g., HHW, tires, scrap metal, electronics) will initially be managed and diverted at the public drop-off and reuse center (5% of the total waste stream); and the program, once mature, may divert up to 9,900 TPY (7–12% of the total waste stream). • Organics that would also be collected at the public drop-off and reuse center are quantified below. • Projected diversion of waste oil and cooking oil: <1%.
2. Recyclables and Waste Drop-off	Provides for the collection of recyclables and waste that is not captured through the curbside collection programs and for those materials that may periodically be generated in large quantities.	Included as part of the Integrated Public Drop-off and Reuse Facility.	• Potential to increase waste diversion from landfill due to co-location of recycling services. Recycling at the Kaua'i Resource Center would be relocated to the RRP to avoid duplication of costs and services.	Included as part of the Integrated Public Drop-off and Reuse Facility.	Included as part of the Integrated Public Drop-off and Reuse Facility.	Recommended as part of the overall RRP: • Upon implementation of the MRF, the majority of recyclables would be collected through curbside collection program.
3. Household Hazardous Waste Depot	Provides for the collection and proper management of household hazardous wastes, including aerosols, batteries, oil, paint, cleaning products, and pesticides.	Included as part of the Integrated Public Drop-off and Reuse Facility. Combined with the electronic waste depot in a 5,000-ft^2 building.	• Potential to increase waste diversion from landfill. • Removes potential materials of concern from landfill and improves leachate quality.	Included as part of the Integrated Public Drop-off and Reuse Facility. Building cost for HHW Depot and Electronic Waste Depot: **$1.25 million.**	Included as part of the Integrated Public Drop-off and Reuse Facility. Offsite management of consolidated materials: **$50,000–$100,000**	Recommended as part of the overall RRP: • Up to 370 TPY (0.25% of the total waste stream) may be diverted.
4. Electronic Waste Depot	Provides for the collection and proper management of electronic waste, including computers and peripherals, monitors, televisions, and cell phones.	Included as part of the Integrated Public Drop-off and Reuse Facility. Combined with the HHW depot in a 5,000-ft^2 building.	• Potential to increase waste diversion from landfill. • Removes potential materials of concern from landfill and improves leachate quality. • Potential for downstream recovery of valuable raw materials.	Included as part of the Integrated Public Drop-off and Reuse Facility. Building cost for HHW Depot and Electronic Waste Depot: **$1.25 million**	Included as part of the Integrated Public Drop-off and Reuse Facility. Offsite management of consolidated materials: **$0**. Costs covered as part of Producer responsibility. County costs approximately $80,000 for event marketing and public outreach.	Recommended as part of the overall RRP: • A 100% increase in the current diversion achieved would divert approximately 200 TPY (0.2% of the total waste stream).
5. Metals Recycling Facility	Provides for the collection, management, and recycling of used metals, including automobiles, white goods, and scrap metal. Onsite processing facility allows separation of waste material types for consolidation and preparation for transport to market.	Drop-off included as part of the Integrated Public Drop-off and Reuse Facility. Area for receiving, processing and storage: 5.5 acres	• Potential to increase waste diversion from landfill. • Removes potential materials of concern from landfill and improves leachate quality. • Provides a processing capacity capable of managing a range of scrap metal and appliances. • Supports the increased diversion of scrap metal from both residential and commercial sources.	Drop-off included as part of the Integrated Public Drop-off and Reuse Facility. Processing area for scrap metal, including equipment: **$1.5–$2 million**	Drop-off included as part of the Integrated Public Drop-off and Reuse Facility. Processing of scrap metal and appliances: **$560,000**	Recommended as part of the overall RRP: • Expected diversion of more than 4,669 TPY (3.2% of the total waste stream).
6. Construction and Demolition Material Processing and Recycling Facility	Provides for the collection and proper management of construction and demolition (C&D) materials. Onsite processing facility allows separation of waste material types for reuse, recycling, consolidation, and preparation for transport to market.	Drop-off included as part of the Integrated Public Drop-off and Reuse Facility. Processing area: approximately 1 acre. Concrete, brick, block, asphalt processing and storage area: 0.84 acre.	• Potential to increase waste diversion from landfill. • Removes potential materials of concern from landfill and improves leachate quality. • Provides the County with on-island processing capacity capable of managing a range of C&D materials. • Supports the increased diversion of C&D materials from both residential and commercial sources.	Drop-off included as part of the Integrated Public Drop-off and Reuse Facility. Processing area for C&D materials including equipment: **$1.43 million**	Drop-off included as part of the Integrated Public Drop-off and Reuse Facility. Processing of C&D materials: **$869,000**	Recommended as part of the overall RRP: • Up to 9,000 tons (6% of the total waste stream) may be diverted.

Component/Facility	Description	Approximate Acreage Required	Benefits	Capital Cost (Estimated)	Annual O&M Costs (Estimated)	Estimated Diversion and Other Comments
7. Used Tire Processing Facility	Provides for the collection and proper management of used tires that are not managed by retailers or other private parties. Onsite processing facility allows for consolidation and baling of used tires for transport to market.	Drop-off included as part of the Integrated Public Drop-off and Reuse Facility. Processing area: approximately 0.4 acre with a 1,000-ft^2 covered structure	• Potential to increase waste diversion from landfill. • Diverts material from landfill and improves leachate quality. • Provides the County with on-island processing capacity capable of managing used tires. • Supports the increased diversion of used tires from both residential and commercial sources.	Drop-off included as part of the Integrated Public Drop-off and Reuse Facility. Processing area for used tires, including equipment: **$252,000**	Drop-off included as part of the Integrated Public Drop-off and Reuse Facility. Processing of used tires: **$165,000**	Recommended as part of the overall RRP: • Approximately 1,482 TPY or 1% of the total waste stream may be diverted.
8. Center for Hard-to-Recycle Materials	Provides for the collection and proper management of a variety of materials, which are typically generated in small quantities and for which there are very limited markets and secondary uses. Separation and storage of waste material types for consolidation and preparation for transport to market, if markets are identified, are provided at reuse building.	Drop-off included as part of the Integrated Public Drop-off and Reuse Facility. Located within the reuse building.	• Potential to increase waste diversion from landfill. • Potentially diverts materials from landfill and improves leachate quality. • Provides the County with an on-island facility capable of managing hard-to-recycle materials, should markets be identified. • Supports the increased diversion of hard-to-recycle materials. • Provided capacity and flexibility to manage potential diversion activities in response to changing market conditions.	Drop-off included as part of the Integrated Public Drop-off and Reuse Facility. Utilize area within the reuse building.	Drop-off included as part of the Integrated Public Drop-off and Reuse Facility. Processing of hard-to-recycle materials: expected to be minimal as most materials are addressed by specific programs: **$100,000**	Recommended as part of the overall RRP: • Less than 1% of the total waste stream may be diverted (1,185 TPY assumed for the purpose of the $/ton analysis).
9. Reuse Center	Provides for community reuse of a wide range of materials diverted from the landfill.	Included as part of the Integrated Public Drop-off and Reuse Facility. Building for Reuse Center/Hard-to-Recycle Material Center: approximately 11,000 ft^2	• Promotes increased reuse and diversion from the landfill. • A wide variety of materials can be managed. • Opportunity for non-profit-operated reuse center.	Included as part of the Integrated Public Drop-off and Reuse Facility.	Included as part of the Integrated Public Drop-off and Reuse Facility.	Recommended as part of the overall RRP: • Less than 1% of the total waste stream may be diverted (1,185 TPY assumed for the purpose of the $/ton analysis).
10. Educational Center	Provides a location for residents to obtain information and observe waste management processes that promote waste reduction, reuse, and recycling for maximizing waste diversion from disposal.	Located within the MRF facility.	• Opportunity for research and increased environmental awareness through educational center.	Included as part of the MRF facility.	Included as part of the Integrated Public Drop-off and Reuse Facility.	Recommended as part of the overall RRP: • No measureable diversion achieved but supports all of the County's waste diversion efforts and programs.
11. Materials Recovery Facility	Processing facility that receives single-stream or fully commingled recyclable materials from the curbside-collection program and other sources, sorts the materials, removes contaminants, densifies, and bales the materials into a form suitable for transport and sale to markets. Either a packaged MRF could be purchased, or a custom facility could be provided. These units comprise a well-developed, mature technology that is a proven successful and reliable process for management of recyclables.	5 acres, including a 35,000-ft^2 building and other site infrastructure and needs such as traffic movements, and storage.	• Provides the County with on-island recyclables processing capacity capable of managing curbside-collected single-stream recyclables. • Encourages recycling through simplification, by eliminating the need for residents and commercial entities to sort recyclables. • Single-stream recycling provides lowest collection costs and potentially increases quantity of recyclables captured. • Capability to process a single stream may simplify the existing drop bin program. • Supports the increased diversion of recyclables from commercial sources plus is capable of processing collected HI-5 containers.	**$8.7 million**	**$950,000** for the proposed MRF. May increase revenues associated with sale of recyclable material (not calculated herein).	Recommended as part of the overall RRP: • Smallest commercially viable single-stream MRF can accommodate Kaua'i's needs. • MRF capacity requirements are estimated to be 26,683 TPY by the end of the planning period (12,418 TPY of curbside-collected residential recyclables plus 14,265 TPY of commercial recyclable materials). This amounts to approximately 17% of the County's overall waste stream. • Mature, well-developed technology
12. Composting Facility	Aerobic composting is considered the most effective and efficient way to manage Kaua'i's organic waste stream, which is composed largely of greenwaste, with additional amounts of food waste, and biosolids.	9 acres minimum: to provide support for windrow composting and storage of composted material, and buffer areas for the projected quantities. Active composting windrows could be relocated to inactive portions of the landfill, thereby minimizing the amount of devoted acreage required at the RRP.	• An organics processing or compost facility provides the County with the opportunity to maximize diversion of organic materials. • At present, only greenwaste is being diverted. Food waste and biosolids can also be effectively managed through windrow composting. • Provides processing capacity for the County's planned curbside-collected greenwaste program. • Can also support potential future curbside collection of residential food waste. With the introduction of increased food waste quantities, process may need to evolve to aerated static pile and/or to a process with greater production control. • Can support the expanded ban on municipal landfill disposal of non-residential greenwaste to include residential waste, and expand the ban to include disposal restrictions at the transfer stations. Locating this facility near the landfill may support this effort. • Establish a central greenwaste and organics processing facility to produce mulch or compost for use by residents.	**$3 million**	**$350,000**	Recommended as part of the overall RRP: • Windrow compost moving to an aerated static pile process is preferred for the mix of organic materials expected to be received for processing. • An estimated 33,812 TPY of organic material may be captured and diverted by the end of the 20-year planning period. This represents an estimated 23% diversion of the total waste stream. • Would not be combined with 13. Anaerobic Digestion of Biomass or 14. Biorefinery Facility.

Component/Facility	Description	Approximate Acreage Required	Benefits	Capital Cost (Estimated)	Annual O&M Costs (Estimated)	Estimated Diversion and Other Comments
13. Anaerobic Digestion of Biomass	Anaerobic digestion (AD) is the biological conversion of organic materials in the absence of oxygen. The process is carried out by microorganisms that convert carbon-containing compounds to biogas, which consists primarily of methane (CH_4) and carbon dioxide (CO_2), with trace amounts of other gases. AD is significantly more mechanized compared to aerobic composting and relies on engineered vessels or reactors to provide the conditions required to maximize waste decomposition and gas generation.	3–4 acres	• Production of biogas, an alternative to fossil fuels that can be used to produce energy. • AD is becoming more common for processing large volumes of food or mixed wastes, which are more difficult to control.	No commercial packaged unit is small enough to effectively manage Kaua'i's waste stream, and therefore the costs would be high: **$12 million**	Due to the small size of facility, costs would be relatively high: **$650,000**	Not recommended as part of the overall RRP: • 90% of organic material generated in Kaua'i is greenwaste and not suitable for anaerobic digestion. With only an estimated 6,200 TPY of suitable organic material available, this technology is not recommended for inclusion in the RRP. • Infrastructure is far more costly than aerobic composting, with marginal benefits for Kaua'i. • Would not be combined with 12. Composting Facility or 14. Biorefinery Facility.
14. Biorefinery Facility	Organic feedstock is pre-processed and fed to a refinery to produce a biofuel. The refinery uses gasification or anaerobic digestion technologies to process homogeneous biomass feedstock. A nearby private facility is expected to come online in the coming years. If the County were to implement a biorefinery, the most likely technology would by AD, discussed above.	Private facility: 25 offsite acres County facility: up to 4 acres	• Production of a biofuel from renewable resources; offsetting fossil fuel use and importation. • Using the private facility: Potential use of paper wastes generated within County as a small portion of the Private facility's overall biomass feedstock. However, impurities (e.g., staples, plastic) may be an issue. • Using a County facility: Potential to design the technology to process greenwaste as well.	Private developer proposing facility adjacent RRP. No capital cost to the County in this situation.	Private developer to discuss technical requirements and financial arrangements with County for use of waste paper as part of their biorefinery feedstock. Potential (likely nominal) revenue stream.	• Private facility: Recommended to pursue a potential arrangement. May have the potential to receive the entire waste paper stream from the County. An estimated 30,000 TPY of waste paper is generated by residential and commercial sources (21% of the total waste stream). • Not recommended to be developed by the County as part of the overall RRP, due to costs. • Would not be combined with 12. Composting Facility or 13. Anaerobic Digestion of Biomass.
15. Landfill Gas to Energy Facility	Combustion of landfill gas in conventional reciprocating engines to generate electric power.	1 acre, including a 4,900-ft^2 building	• Supports reduction of GHG emissions from the landfill. • Production of a biofuel from renewable resources; offsetting fossil fuel use and importation. • Can be implemented modularly to match LFG generation rates over time and reduce up-front costs. • Approximately 3.75 MW of electricity generated at peak power, which is equivalent to powering about 2,200 homes. • Reduction in emissions equivalent to 540,000 metric tons CO_2/year. • Revenue generation estimated at $1.7 million annually (initial phase) and $4 million annually (ultimate capacity).	**$2.3 million** for initial phase **$7.0 million** total capital cost at the ultimate landfill capacity	**$133,000** for initial phase, increasing to **$312,000** at the ultimate landfill capacity.	Recommended as part of the overall RRP: • Annual electrical production is estimated to be worth $1.73 million annually during the initial phase, increasing to $4.06 million annually at full capacity and provide electricity supply for about 2,200 homes. • Efforts to divert organics from the landfill may reduce the anticipated quantities of landfill gases generated. Modular installation of generators, as required, will protect the County against over-investment.
16. Waste to Energy Facility	Waste to energy (WtE) is a form of energy recovery whereby energy is created in the form of electricity or heat from the direct incineration of waste. Residual waste not treated through the WtE facility, as well as the combustion ash, would be deposited into the landfill.	6–8 acres	• Production of energy • Reduction of the waste feedstock by up to 95% by volume. • Potential to manage approx. 96,000 TPY (including commercial wastes) or about 70% of the County's total waste stream. Allowing for 25% non-combustible waste, 72,000 tons of waste could be diverted from landfill.	**$150 million** (100,000 TPY)	**$120 per ton**, net of energy revenues	Not recommended at this time as part of the overall RRP: • Expensive technology that also carries a significant financial risk associated with either undersizing or oversizing the WtE facility, based on assumptions made regarding the quantities of the commercial waste stream that would be available as a feedstock. • Would not be combined with 17. Waste to Fuel Facility.
17. Waste to Fuel Facility	Waste-to-fuel systems involve the processing of MSW to produce a fuel and subsequent use of that fuel as a substitute for some of the fossil fuels in utility power generation, industrial manufacturing (e.g., cement kilns), and institutional applications (e.g., district or commercial water heating). This can include a wide range of proprietary processes to produce a refuse-derived fuel (RDF), the final stage of which may include the densification of the RDF into pellets or new applications of technologies like gasification, which produces a syngas, to the thermal destruction of municipal waste.	3–4 acres	• RDF processing could process up to 69% of County's waste stream. RDF is produced in situations where markets are remote from the point of generation and this alternate fuel source requires being transported longer distance. • Gasification – all components of typical MSW can be fed into, but only a fraction can be utilized. This process produces a combustible synthetic gas (syngas) that can fuel an internal-combustion engine, gas turbine, or boiler, under excess-air conditions.	RDF plant: > **$50 million.** For gasification, no reasonable estimates of capital costs are available, because no commercial gasification units operating in North America use municipal solid waste as a feedstock.	Operating costs for an RDF facility could be investigated, if requested. For gasification, no reasonable estimates of capital costs are available, because no commercial gasification units operating in North America use municipal solid waste as a feedstock.	Not recommended as part of the overall RRP: RDF: • Lack of market for RDF product. • High capital cost for marginal benefit. Gasification: • No commercial gasification units are operating in North America that use municipal solid waste as a feedstock. • Would not be combined with 16. Waste to Energy Facility.

B SIZE 11" x 17" (279.4mm x 431.8mm)

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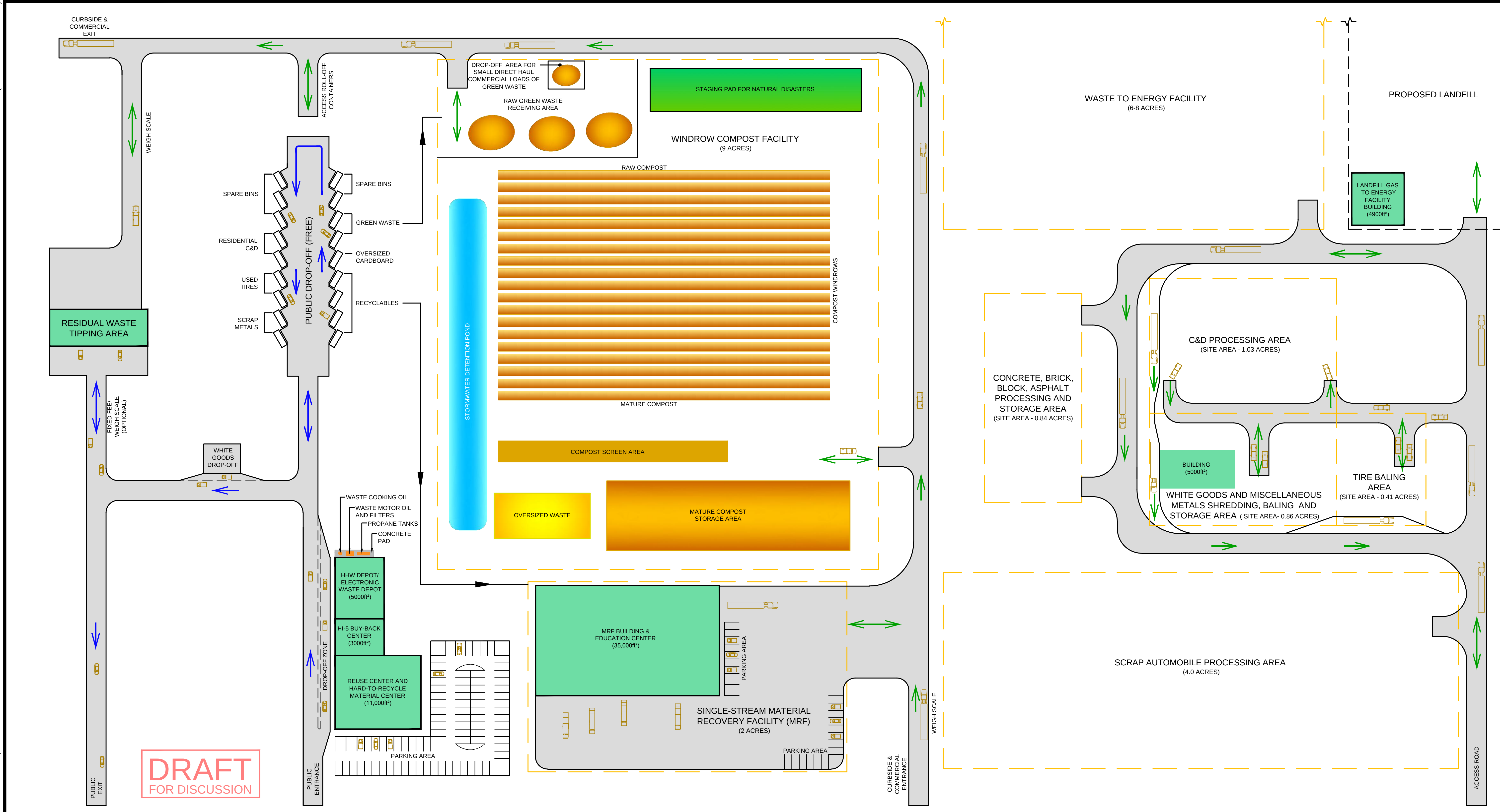

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ALL MEASUREMENTS MUST BE OBTAINED FROM STATED DIMENSIONS.

Legend

- CURBSIDE/COMMERCIAL/ SERVICE/TRANSFER VEHICLES
- RESIDENTIAL/PUBLIC/ CUSTOMER VEHICLES
- SMALL VEHICLE
- PICK-UP TRUCK
- COLLECTION VEHICLE
- TRANSFER TRAILER

PUBLIC DROP-OFF MATERIAL

TYPE OF MATERIAL	PLACE TO GO
GREEN WASTE	--->TO COMPOST FACILITY
RECYCLABLES	--->TO MRF
ELECTRONIC WASTE	--->PROCESSING/MARKET
HOUSE HAZARDOUS WASTE	--->PROCESSING/MARKET
SCRAP METALS	--->PROCESSING/MARKET
RESIDENTIAL C&D	--->PROCESSING/MARKET
USED TIRES	--->PROCESSING/MARKET
HARD-TO-RECYCLE MATERIALS	--->ON-SITE STORAGE/MARKET

AECOM

County of Kaua'i
Resource Recovery Park Feasibility Study

RESOURCE RECOVERY PARK SCHEMATIC

PROJECT NUMBER	DATE	FIGURE
60221907	**December, 2012**	**7**

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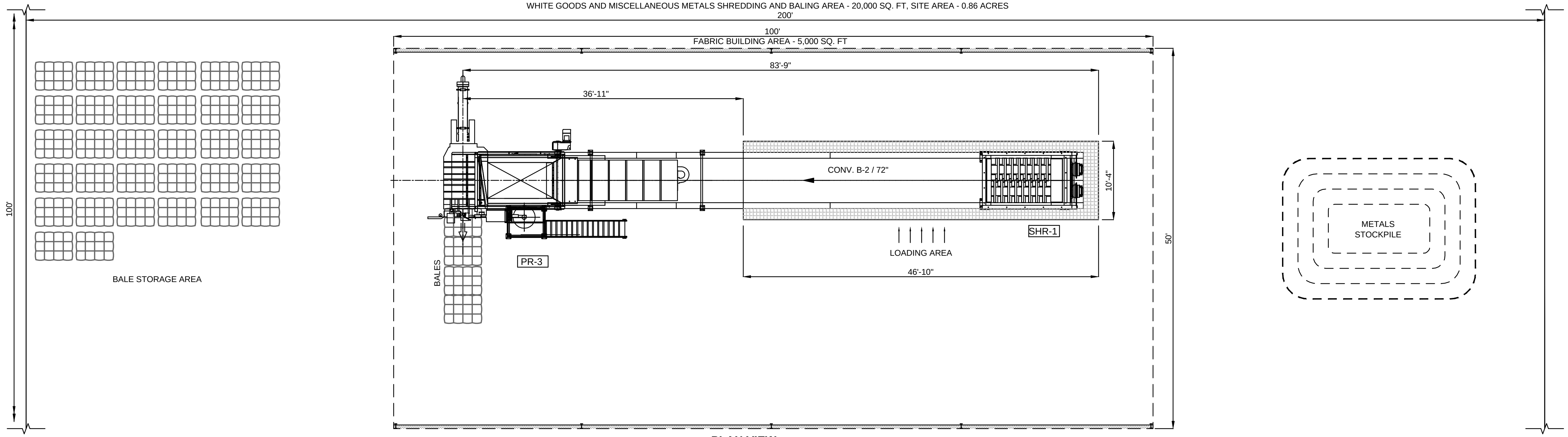
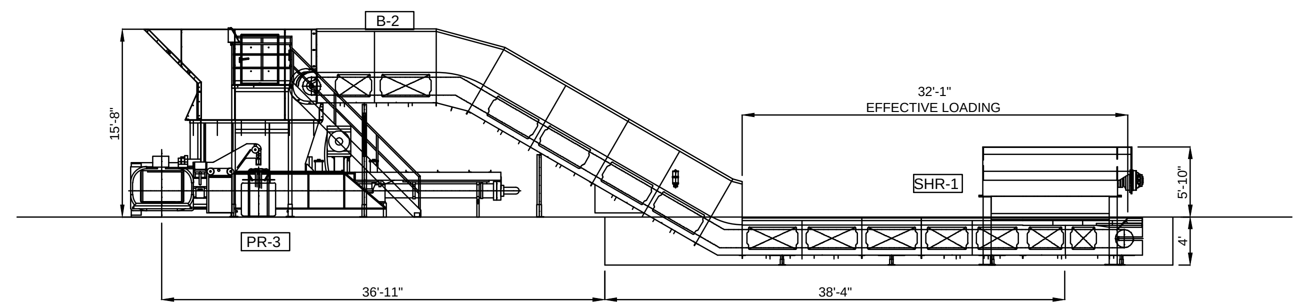
Appendix A
Schematics for C&D Processing Plant, Concrete Crushing/Metals/Tires Processing Plant

WHITE GOODS AND MISCELLANEOUS METALS SHREDDING AND BALING AREA - 20,000 SQ. FT, SITE AREA - 0.86 ACRES



PLAN VIEW

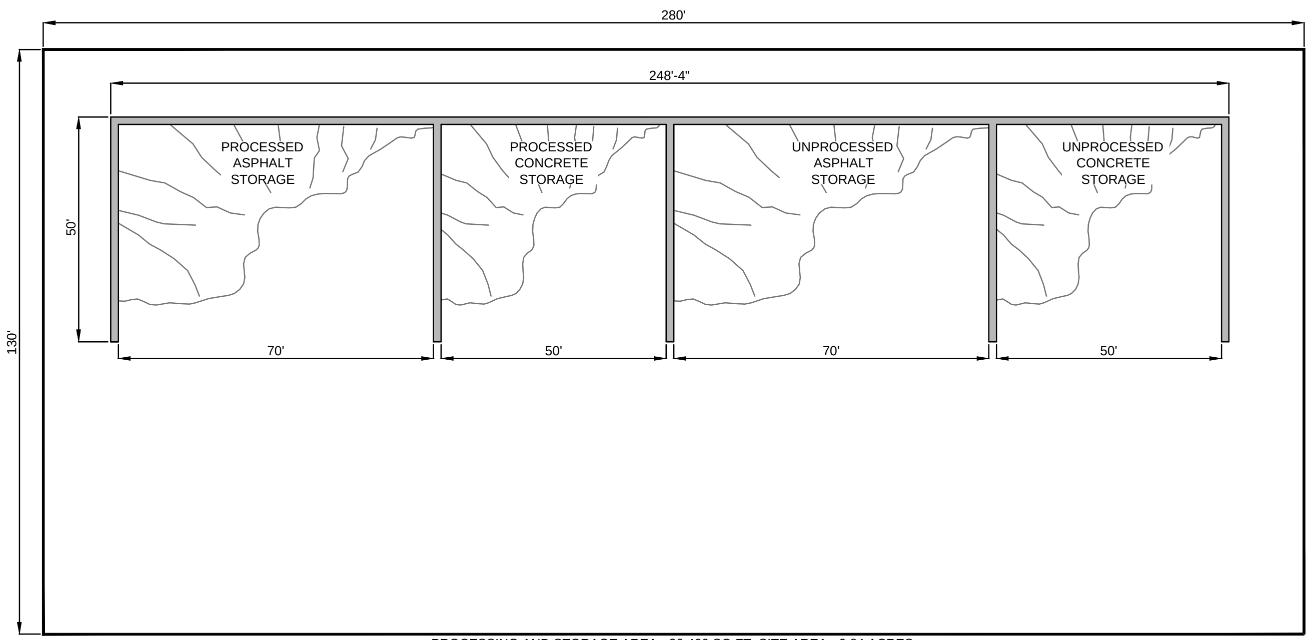
EQUIPMENT LIST	
EQUIP No	DESCRIPTION
SHR-1	DUAL SHAFT SHREDDER
B-2	BALER FEED CONVEYOR
PR-3	TWO RAM BALER



ELEVATION

0 8' 16'

TYPICAL WHITE GOODS AND MISCELLANEOUS METALS SHREDDING AND BALING SYSTEM

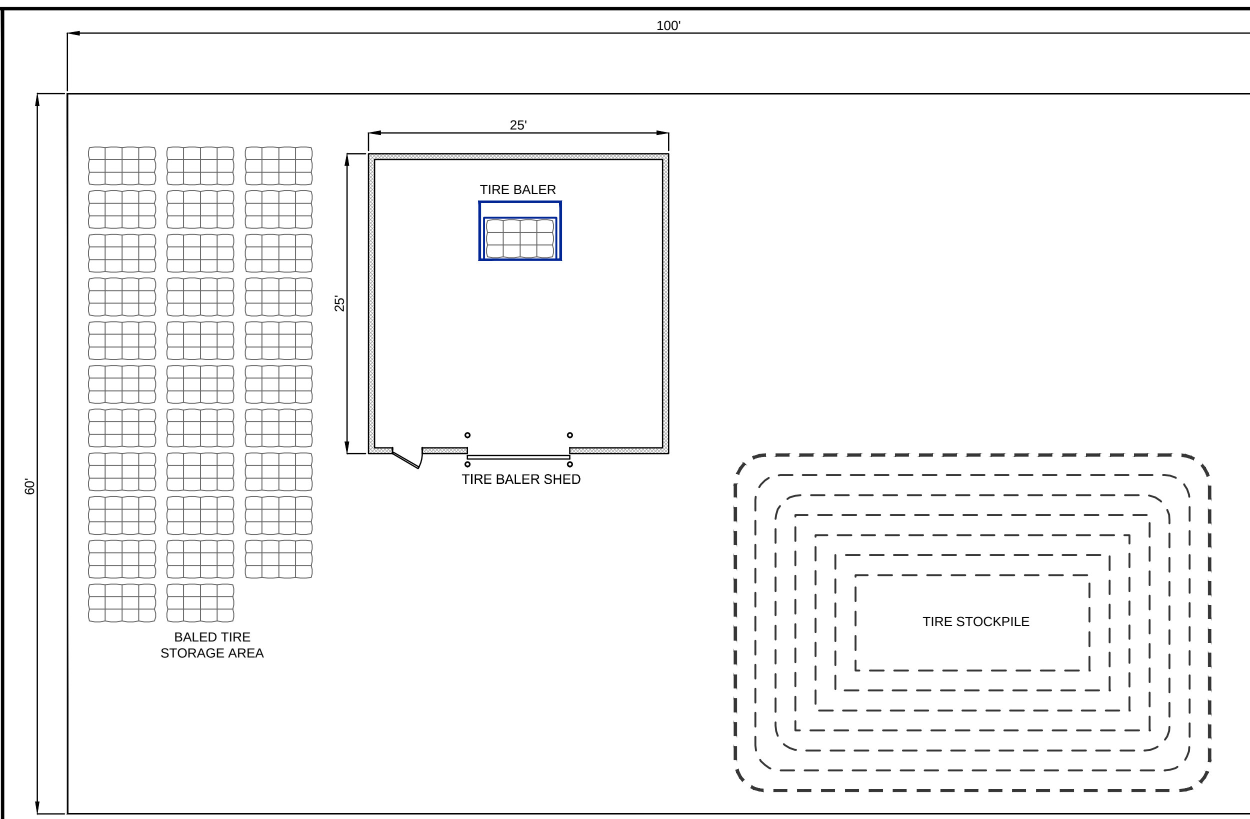


PROCESSING AND STORAGE AREA - 36,400 SQ.FT, SITE AREA - 0.84 ACRES

PLAN VIEW

CONCRETE, BRICK, BLOCK, AND ASPHALT PROCESSING AND STORAGE AREA

0 16' 32'



TIRE STORAGE AND BALING AREA - 6,000 SQ.FT, SITE AREA - 0.41 ACRES

PLAN VIEW

TYPICAL TIRE BALING SYSTEM

0 8' 16'

AECOM

PROJECT

County of Kaua'i
Solid Waste Division

CONSULTANT

AECOM
300-300 Town Centre Blvd,
Markham, Ontario, Canada L3R 5Z6
905.477.8400 tel 905.477.1456 fax
www.aecom.com

LEGEND:

REGISTRATION

ISSUE/REVISION

I/R	DATE	DESCRIPTION

KEY PLAN

PROJECT NUMBER

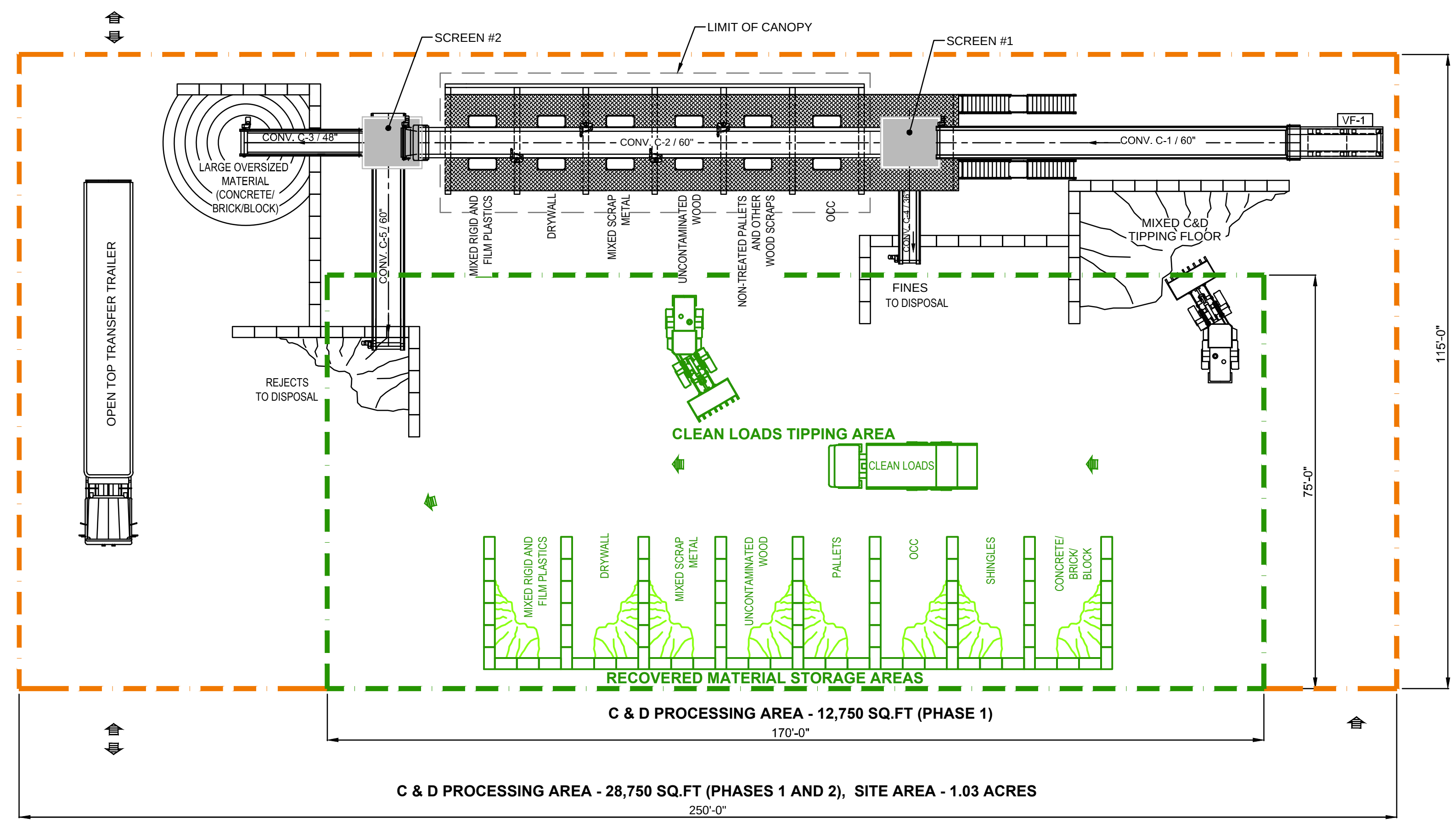
60221907

SHEET TITLE

TYPICAL PLANT LAYOUT

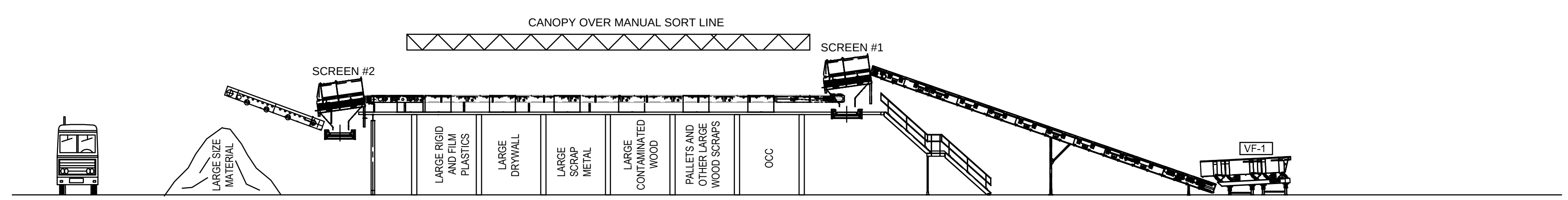
FIGURE NUMBER

Figure A-1



PLAN VIEW

0 16' 32'



ELEVATION

0 16' 32'

AECOM

PROJECT

County of Kaua'i
Solid Waste Division

CONSULTANT

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300-300 Town Centre Blvd,
Markham, Ontario, Canada L3R 5Z6
905.477.8400 tel 905.477.1456 fax
www.aecom.com

LEGEND:

- LIMIT OF PHASE 1 PROCESSING AREA
- LIMIT OF PHASE 2 PROCESSING AREA

REGISTRATION

ISSUE/REVISION

I/R	DATE	DESCRIPTION

KEY PLAN

PROJECT NUMBER

60221907

SHEET TITLE

C&D PROCESSING AREA

FIGURE NUMBER

Figure A-2

ANSI D 864mm x 559mm

Approved: Checked: Designer: Project Management Initials:

Last saved by: WANGV(2012-11-05) Last Plotted: 2012-11-05
Filename: P:\60221907\000-CADD\040 CADD-BIM WIP\041-REPORT FIGURES\60221907-FIG A-2-C&D PROCESSING PLANT.DWG

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Appendix B
LFG LandGEM Analysis

Emission Reductions and Environmental and Energy Benefits for Landfill Gas Energy Projects

For electricity generation projects, enter megawatt (MW) capacity: 3.75

\- OR -

For direct-use projects, enter landfill gas utilized by project: ____ million standard cubic feet per day (mmscfd) or ____ standard cubic feet per minute (scfm)

Direct Equivalent Emissions Reduced [Reduction of methane emitted directly from the landfill]		Avoided Equivalent Emissions Reduced [Offset of carbon dioxide from avoiding the use of fossil fuels]		Total Equivalent Emissions Reduced [Total = Direct + Avoided]		
$MMTCO_2E/yr$ million metric tons of carbon dioxide equivalents per year	tons CH_4/yr tons of methane per year	$MMTCO_2E/yr$ million metric tons of carbon dioxide equivalents per year	tons CO_2/yr tons of carbon dioxide per year	$MMTCO_2E/yr$ million metric tons of carbon dioxide equivalents per year	tons CH_4/yr tons of methane per year	tons CO_2/yr tons of carbon dioxide per year
0.1423	7,470	0.0161	17,731	0.1584	7,470	17,731

Direct: Equivalent to any one of the following annual benefits:		Avoided: Equivalent to any one of the following annual benefits:		Total: Equivalent to any one of the following annual benefits:	
Environmental Benefits		Environmental Benefits		Environmental Benefits	
• Annual greenhouse gas emissions from __ passenger vehicles:	27,905	• Annual greenhouse gas emissions from __ passenger vehicles:	3,154	• Annual greenhouse gas emissions from __ passenger vehicles:	31,059
• Carbon sequestered annually by __ acres of pine or fir forests:	30,345	• Carbon sequestered annually by __ acres of pine or fir forests:	3,430	• Carbon sequestered annually by __ acres of pine or fir forests:	33,774
• CO2 emissions from burning __ railcars' worth of coal:	775	• CO2 emissions from burning __ railcars' worth of coal:	88	• CO2 emissions from burning __ railcars' worth of coal:	863
• CO2 emissions from __ gallons of gasoline consumed:	15,954,806	• CO2 emissions from __ gallons of gasoline consumed:	1,803,293	• CO2 emissions from __ gallons of gasoline consumed:	17,758,099

Energy Benefits (based on project size entered)**:**

• Powering __ homes: 2,214

View Calculations and References

For additional environmental benefit options, view the Greenhouse Gas Equivalencies Calculator on the EPA Clean Energy website.

Estimated LFG Generation Rate and Electric Generating Capacity

Client: Kaua'i, Hawai'i **Date:** 31-Aug-12
Site: Ma'alo RRP **By:** pjw
Project: LFG / LFGTE **Check:**

Year	Cumulative Waste in place (tons)	Estimated LFG Generation Rate yrs 1 - 80 (ft^3/min)	Estimated LFG Generation Rate yrs 81 - 160 (ft^3/min)	Estimated LFG Generation Rate yrs 161 - 240 (ft^3/min)	Estimated LFG Generation Rate yrs 241 - 264	Estimated LFG Generation Rate Total (ft^3/min)	Electric Generating Capacity (kW)	
1	66,000	0	0	0	0	0	0	
2	132,000	78	0	0	0	78	257	
3	198,000	150	0	0	0	150	496	
4	264,000	218	0	0	0	218	719	
5	330,000	281	0	0	0	281	927	
6	396,000	340	0	0	0	340	1,120	
7	462,000	394	0	0	0	394	1,300	1st Genset on-line
8	528,000	445	0	0	0	445	1,468	
9	594,000	493	0	0	0	493	1,624	
10	660,000	537	0	0	0	537	1,770	
11	726,000	578	0	0	0	578	1,905	
12	792,000	616	0	0	0	616	2,031	
13	858,000	652	0	0	0	652	2,149	
14	924,000	685	0	0	0	685	2,259	
15	990,000	716	0	0	0	716	2,361	
16	1,056,000	745	0	0	0	745	2,456	
17	1,122,000	772	0	0	0	772	2,544	
18	1,188,000	797	0	0	0	797	2,627	2nd Genset on-line
19	1,254,000	820	0	0	0	820	2,704	
20	1,320,000	842	0	0	0	842	2,775	
21	1,386,000	862	0	0	0	862	2,842	
22	1,452,000	881	0	0	0	881	2,904	
23	1,518,000	898	0	0	0	898	2,962	
24	1,584,000	915	0	0	0	915	3,016	
25	1,650,000	930	0	0	0	930	3,066	
26	1,716,000	944	0	0	0	944	3,113	
27	1,782,000	957	0	0	0	957	3,156	
28	1,848,000	970	0	0	0	970	3,197	
29	1,914,000	981	0	0	0	981	3,234	
30	1,980,000	992	0	0	0	992	3,270	
31	2,046,000	1,002	0	0	0	1,002	3,302	
32	2,112,000	1,011	0	0	0	1,011	3,333	
33	2,178,000	1,020	0	0	0	1,020	3,361	
34	2,244,000	1,028	0	0	0	1,028	3,388	
35	2,310,000	1,035	0	0	0	1,035	3,412	
36	2,376,000	1,042	0	0	0	1,042	3,435	
37	2,442,000	1,049	0	0	0	1,049	3,457	
38	2,508,000	1,055	0	0	0	1,055	3,477	
39	2,574,000	1,060	0	0	0	1,060	3,495	
40	2,640,000	1,065	0	0	0	1,065	3,513	
41	2,706,000	1,070	0	0	0	1,070	3,529	
42	2,772,000	1,075	0	0	0	1,075	3,544	

43	2,838,000	1,079	0	0	0	1,079	3,558	
44	2,904,000	1,083	0	0	0	1,083	3,571	
45	2,970,000	1,087	0	0	0	1,087	3,583	
46	3,036,000	1,090	0	0	0	1,090	3,594	
47	3,102,000	1,093	0	0	0	1,093	3,605	
48	3,168,000	1,096	0	0	0	1,096	3,614	
49	3,234,000	1,099	0	0	0	1,099	3,624	
50	3,300,000	1,102	0	0	0	1,102	3,632	
51	3,366,000	1,104	0	0	0	1,104	3,640	
52	3,432,000	1,106	0	0	0	1,106	3,647	
53	3,498,000	1,108	0	0	0	1,108	3,654	
54	3,564,000	1,110	0	0	0	1,110	3,661	
55	3,630,000	1,112	0	0	0	1,112	3,667	
56	3,696,000	1,114	0	0	0	1,114	3,672	
57	3,762,000	1,115	0	0	0	1,115	3,677	
58	3,828,000	1,117	0	0	0	1,117	3,682	
59	3,894,000	1,118	0	0	0	1,118	3,687	
60	3,960,000	1,120	0	0	0	1,120	3,691	
61	4,026,000	1,121	0	0	0	1,121	3,695	
62	4,092,000	1,122	0	0	0	1,122	3,698	
63	4,158,000	1,123	0	0	0	1,123	3,702	
64	4,224,000	1,124	0	0	0	1,124	3,705	
65	4,290,000	1,125	0	0	0	1,125	3,708	
66	4,356,000	1,126	0	0	0	1,126	3,711	
67	4,422,000	1,126	0	0	0	1,126	3,713	
68	4,488,000	1,127	0	0	0	1,127	3,716	
69	4,554,000	1,128	0	0	0	1,128	3,718	
70	4,620,000	1,128	0	0	0	1,128	3,720	
71	4,686,000	1,129	0	0	0	1,129	3,722	
72	4,752,000	1,129	0	0	0	1,129	3,723	
73	4,818,000	1,130	0	0	0	1,130	3,725	
74	4,884,000	1,130	0	0	0	1,130	3,727	
75	4,950,000	1,131	0	0	0	1,131	3,728	
76	5,016,000	1,131	0	0	0	1,131	3,729	
77	5,082,000	1,132	0	0	0	1,132	3,731	
78	5,148,000	1,132	0	0	0	1,132	3,732	
79	5,214,000	1,132	0	0	0	1,132	3,733	
80	5,280,000	1,133	0	0	0	1,133	3,734	
81	5,346,000	1,133	0	0	0	1,133	3,735	
82	5,412,000	1,055	78	0	0	1,133	3,736	
83	5,478,000	983	150	0	0	1,133	3,737	
84	5,544,000	916	218	0	0	1,134	3,737	
85	5,610,000	853	281	0	0	1,134	3,738	
86	5,676,000	794	340	0	0	1,134	3,739	
87	5,742,000	740	394	0	0	1,134	3,739	
88	5,808,000	689	445	0	0	1,134	3,740	
89	5,874,000	642	493	0	0	1,135	3,740	
90	5,940,000	598	537	0	0	1,135	3,741	
91	6,006,000	557	578	0	0	1,135	3,741	
92	6,072,000	519	616	0	0	1,135	3,742	
93	6,138,000	483	652	0	0	1,135	3,742	
94	6,204,000	450	685	0	0	1,135	3,743	
95	6,270,000	419	716	0	0	1,135	3,743	
96	6,336,000	391	745	0	0	1,135	3,743	
97	6,402,000	364	772	0	0	1,136	3,744	3rd Genset on-line

98	6,468,000	339	797	0	0	1,136	3,744
99	6,534,000	316	820	0	0	1,136	3,744
100	6,600,000	294	842	0	0	1,136	3,744
101	6,666,000	274	862	0	0	1,136	3,745
102	6,732,000	255	881	0	0	1,136	3,745
103	6,798,000	238	898	0	0	1,136	3,745
104	6,864,000	221	915	0	0	1,136	3,745
105	6,930,000	206	930	0	0	1,136	3,745
106	6,996,000	192	944	0	0	1,136	3,746
107	7,062,000	179	957	0	0	1,136	3,746
108	7,128,000	167	970	0	0	1,136	3,746
109	7,194,000	155	981	0	0	1,136	3,746
110	7,260,000	145	992	0	0	1,136	3,746
111	7,326,000	135	1,002	0	0	1,136	3,746
112	7,392,000	125	1,011	0	0	1,136	3,746
113	7,458,000	117	1,020	0	0	1,136	3,746
114	7,524,000	109	1,028	0	0	1,136	3,746
115	7,590,000	101	1,035	0	0	1,136	3,747
116	7,656,000	94	1,042	0	0	1,136	3,747
117	7,722,000	88	1,049	0	0	**1,137**	3,747
118	7,788,000	82	1,055	0	0	**1,137**	3,747
119	7,854,000	76	1,060	0	0	**1,137**	3,747
120	7,920,000	71	1,065	0	0	**1,137**	3,747
121	7,986,000	66	1,070	0	0	**1,137**	3,747
122	8,052,000	62	1,075	0	0	**1,137**	3,747
123	8,118,000	57	1,079	0	0	**1,137**	3,747
124	8,184,000	53	1,083	0	0	**1,137**	3,747
125	8,250,000	50	1,087	0	0	**1,137**	3,747
126	8,316,000	46	1,090	0	0	**1,137**	3,747
127	8,382,000	43	1,093	0	0	**1,137**	3,747
128	8,448,000	40	1,096	0	0	**1,137**	3,747
129	8,514,000	38	1,099	0	0	**1,137**	3,747
130	8,580,000	35	1,102	0	0	**1,137**	3,747
131	8,646,000	33	1,104	0	0	**1,137**	3,747
132	8,712,000	30	1,106	0	0	**1,137**	3,747
133	8,778,000	28	1,108	0	0	**1,137**	3,747
134	8,844,000	26	1,110	0	0	**1,137**	3,747
135	8,910,000	24	1,112	0	0	**1,137**	3,747
136	8,976,000	23	1,114	0	0	**1,137**	3,747
137	9,042,000	21	1,115	0	0	**1,137**	3,747
138	9,108,000	20	1,117	0	0	**1,137**	3,747
139	9,174,000	18	1,118	0	0	**1,137**	3,747
140	9,240,000	17	1,120	0	0	**1,137**	3,748
141	9,306,000	16	1,121	0	0	**1,137**	3,748
142	9,372,000	15	1,122	0	0	**1,137**	3,748
143	9,438,000	14	1,123	0	0	**1,137**	3,748
144	9,504,000	13	1,124	0	0	**1,137**	3,748
145	9,570,000	12	1,125	0	0	**1,137**	3,748
146	9,636,000	11	1,126	0	0	**1,137**	3,748
147	9,702,000	11	1,126	0	0	**1,137**	3,748
148	9,768,000	10	1,127	0	0	**1,137**	3,748
149	9,834,000	9	1,128	0	0	**1,137**	3,748
150	9,900,000	9	1,128	0	0	**1,137**	3,748
151	9,966,000	8	1,129	0	0	**1,137**	3,748
152	10,032,000	7	1,129	0	0	**1,137**	3,748

153	10,098,000	7	1,130	0	0	**1,137**	3,748
154	10,164,000	6	1,130	0	0	**1,137**	3,748
155	10,230,000	6	1,131	0	0	**1,137**	3,748
156	10,296,000	6	1,131	0	0	**1,137**	3,748
157	10,362,000	5	1,132	0	0	**1,137**	3,748
158	10,428,000	5	1,132	0	0	**1,137**	3,748
159	10,494,000	5	1,132	0	0	**1,137**	3,748
160	10,560,000	4	1,133	0	0	**1,137**	3,748
161	10,626,000	4	1,133	0	0	**1,137**	3,748
162	10,692,000	4	1,055	78	0	**1,137**	3,748
163	10,758,000	3	983	150	0	**1,137**	3,748
164	10,824,000	3	916	218	0	**1,137**	3,748
165	10,890,000	3	853	281	0	**1,137**	3,748
166	10,956,000	3	794	340	0	**1,137**	3,748
167	11,022,000	3	740	394	0	**1,137**	3,748
168	11,088,000	2	689	445	0	**1,137**	3,748
169	11,154,000	2	642	493	0	**1,137**	3,748
170	11,220,000	2	598	537	0	**1,137**	3,748
171	11,286,000	2	557	578	0	**1,137**	3,748
172	11,352,000	2	519	616	0	**1,137**	3,748
173	11,418,000	2	483	652	0	**1,137**	3,748
174	11,484,000	2	450	685	0	**1,137**	3,748
175	11,550,000	1	419	716	0	**1,137**	3,748
176	11,616,000	1	391	745	0	**1,137**	3,748
177	11,682,000	1	364	772	0	**1,137**	3,748
178	11,748,000	1	339	797	0	**1,137**	3,748
179	11,814,000	1	316	820	0	**1,137**	3,748
180	11,880,000	1	294	842	0	**1,137**	3,748
181	11,946,000	1	274	862	0	**1,137**	3,748
182	12,012,000	1	255	881	0	**1,137**	3,748
183	12,078,000	1	238	898	0	**1,137**	3,748
184	12,144,000	1	221	915	0	**1,137**	3,748
185	12,210,000	1	206	930	0	**1,137**	3,748
186	12,276,000	1	192	944	0	**1,137**	3,748
187	12,342,000	1	179	957	0	**1,137**	3,748
188	12,408,000	1	167	970	0	**1,137**	3,748
189	12,474,000	1	155	981	0	**1,137**	3,748
190	12,540,000	1	145	992	0	**1,137**	3,748
191	12,606,000	0	135	1,002	0	**1,137**	3,748
192	12,672,000	0	125	1,011	0	1,137	3,748
193	12,738,000	0	117	1,020	0	1,137	3,748
194	12,804,000	0	109	1,028	0	1,137	3,748
195	12,870,000	0	101	1,035	0	1,137	3,748
196	12,936,000	0	94	1,042	0	1,137	3,748
197	13,002,000	0	88	1,049	0	**1,137**	3,748
198	13,068,000	0	82	1,055	0	**1,137**	3,748
199	13,134,000	0	76	1,060	0	**1,137**	3,748
200	13,200,000	0	71	1,065	0	**1,137**	3,748
201	13,266,000	0	66	1,070	0	**1,137**	3,748
202	13,332,000	0	62	1,075	0	**1,137**	3,749
203	13,398,000	0	57	1,079	0	**1,137**	3,749
204	13,464,000	0	53	1,083	0	**1,137**	3,749
205	13,530,000	0	50	1,087	0	**1,137**	3,749
206	13,596,000	0	46	1,090	0	**1,137**	3,749
207	13,662,000	0	43	1,093	0	**1,137**	3,749

208	13,728,000	0	40	1,096	0	**1,137**	3,749	
209	13,794,000	0	38	1,099	0	**1,137**	3,749	
210	13,860,000	0	35	1,102	0	**1,137**	3,749	
211	13,926,000	0	33	1,104	0	**1,137**	3,749	
212	13,992,000	0	30	1,106	0	**1,137**	3,749	
213	14,058,000	0	28	1,108	0	**1,137**	3,749	
214	14,124,000	0	26	1,110	0	**1,137**	3,749	
215	14,190,000	0	24	1,112	0	**1,137**	3,749	
216	14,256,000	0	23	1,114	0	**1,137**	3,749	
217	14,322,000	0	21	1,115	0	**1,137**	3,749	
218	14,388,000	0	20	1,117	0	**1,137**	3,749	
219	14,454,000	0	18	1,118	0	**1,137**	3,749	
220	14,520,000	0	17	1,120	0	**1,137**	3,749	
221	14,586,000	0	16	1,121	0	**1,137**	3,749	
222	14,652,000	0	15	1,122	0	**1,137**	3,750	
223	14,718,000	0	14	1,123	0	**1,137**	3,750	
224	14,784,000	0	13	1,124	0	**1,137**	3,750	
225	14,850,000	0	12	1,125	0	**1,137**	3,750	
226	14,916,000	0	11	1,126	0	**1,137**	3,750	
227	14,982,000	0	11	1,126	0	**1,137**	3,750	
228	15,048,000	0	10	1,127	0	**1,137**	3,750	
229	15,114,000	0	9	1,128	0	**1,137**	3,750	
230	15,180,000	0	9	1,128	0	**1,137**	3,750	
231	15,246,000	0	8	1,129	0	**1,137**	3,750	
232	15,312,000	0	7	1,129	0	**1,137**	3,750	
233	15,378,000	0	7	1,130	0	**1,137**	3,750	
234	15,444,000	0	6	1,130	0	**1,137**	3,749	
235	15,510,000	0	6	1,131	0	**1,137**	3,749	
236	15,576,000	0	6	1,131	0	**1,137**	3,749	
237	15,642,000	0	5	1,132	0	**1,137**	3,749	
238	15,708,000	0	5	1,132	0	**1,137**	3,749	
239	15,774,000	0	5	1,132	0	**1,137**	3,749	
240	15,840,000	0	4	1,133	0	**1,137**	3,749	
241	15,906,000	0	4	1,133	0	**1,137**	3,749	1st Genset off-line
242	15,972,000	0	4	1,055	78	1,059	3,493	
243	16,038,000	0	3	983	150	987	3,253	
244	16,104,000	0	3	916	218	919	3,030	
245	16,170,000	0	3	853	281	856	2,823	
246	16,236,000	0	3	794	340	798	2,629	2nd Genset off-line
247	16,302,000	0	3	740	394	743	2,449	
248	16,368,000	0	2	689	445	692	2,282	
249	16,434,000	0	2	642	493	645	2,125	
250	16,500,000	0	2	598	537	601	1,980	
251	16,566,000	0	2	557	578	559	1,844	
252	16,632,000	0	2	519	616	521	1,718	
253	16,698,000	0	2	483	652	485	1,600	
254	16,764,000	0	2	450	685	452	1,491	
255	16,830,000	0	1	419	716	421	1,389	
256	16,896,000	0	1	391	745	392	1,294	
257	16,962,000	0	1	364	772	366	1,205	3rd Genset off-line
258	17,028,000	0	1	339	797	340	1,122	
259	17,094,000	0	1	316	820	317	1,046	
260	17,160,000	0	1	294	842	295	974	
261	17,226,000	0	1	274	862	275	907	
262	17,292,000	0	1	255	881	256	845	

263	17,358,000	0	1	238	898	239	788
264	17,424,000	0	1	221	915	223	734
265	17,424,000	0	1	206	930	207	683
266	17,424,000	0	1	192	866	193	637
267	17,424,000	0	1	179	807	180	593
268	17,424,000	0	1	167	752	168	553
269	17,424,000	0	1	155	700	156	515
270	17,424,000	0	1	145	652	146	480
271	17,424,000	0	0	135	607	136	447
272	17,424,000	0	0	125	566	126	417
273	17,424,000	0	0	117	527	118	388
274	17,424,000	0	0	109	491	110	362
275	17,424,000	0	0	101	457	102	337
276	17,424,000	0	0	94	426	95	314
277	17,424,000	0	0	88	397	89	293
278	17,424,000	0	0	82	369	83	273
279	17,424,000	0	0	76	344	77	255
280	17,424,000	0	0	71	321	72	237
281	17,424,000	0	0	66	299	67	221
282	17,424,000	0	0	62	278	63	206
283	17,424,000	0	0	57	259	58	192
284	17,424,000	0	0	53	241	54	179
285	17,424,000	0	0	50	225	51	167
286	17,424,000	0	0	46	209	47	156
287	17,424,000	0	0	43	195	44	146
288	17,424,000	0	0	40	182	41	136
289	17,424,000	0	0	38	169	38	127
290	17,424,000	0	0	35	158	36	118
291	17,424,000	0	0	33	147	33	110
292	17,424,000	0	0	30	137	31	103
293	17,424,000	0	0	28	127	29	96
294	17,424,000	0	0	26	119	27	90
295	17,424,000	0	0	24	111	25	84
296	17,424,000	0	0	23	103	24	78
297	17,424,000	0	0	21	96	22	73
298	17,424,000	0	0	20	89	21	68
299	17,424,000	0	0	18	83	19	64
300	17,424,000	0	0	17	77	18	60
301	17,424,000	0	0	16	72	17	56
302	17,424,000	0	0	15	67	16	53
303	17,424,000	0	0	14	63	15	50
304	17,424,000	0	0	13	58	14	46
305	17,424,000	0	0	12	54	13	43
306	17,424,000	0	0	11	51	12	41
307	17,424,000	0	0	11	47	12	38
308	17,424,000	0	0	10	44	11	36
309	17,424,000	0	0	9	41	10	33
310	17,424,000	0	0	9	38	10	31
311	17,424,000	0	0	8	35	9	29
312	17,424,000	0	0	7	33	8	28
313	17,424,000	0	0	7	31	8	26
314	17,424,000	0	0	6	29	7	24
315	17,424,000	0	0	6	27	7	23
316	17,424,000	0	0	6	25	7	22
317	17,424,000	0	0	5	23	6	20

318	17,424,000	0	0	5	22	6	19
319	17,424,000	0	0	5	20	5	18
320	17,424,000	0	0	4	19	5	17
321	17,424,000	0	0	4	17	5	16
322	17,424,000	0	0	4	16	5	15
323	17,424,000	0	0	3	15	4	14
324	17,424,000	0	0	3	14	4	14
325	17,424,000	0	0	3	13	4	13
326	17,424,000	0	0	3	12	4	12
327	17,424,000	0	0	3	11	3	12
328	17,424,000	0	0	2	11	3	11
329	17,424,000	0	0	2	10	3	10
330	17,424,000	0	0	2	9	3	10
331	17,424,000	0	0	2	9	3	9
332	17,424,000	0	0	2	8	3	9
333	17,424,000	0	0	2	7	3	9
334	17,424,000	0	0	2	7	2	8
335	17,424,000	0	0	1	6	2	8
336	17,424,000	0	0	1	6	2	8
337	17,424,000	0	0	1	6	2	7
338	17,424,000	0	0	1	5	2	7
339	17,424,000	0	0	1	5	2	7
340	17,424,000	0	0	1	5	2	6
341	17,424,000	0	0	1	4	2	6
342	17,424,000	0	0	1	4	2	6
343	17,424,000	0	0	1	4	2	6
344	17,424,000	0	0	1	3	2	6
345	17,424,000	0	0	1	3	2	5
346	17,424,000	0	0	1	3	2	5
347	17,424,000	0	0	1	3	2	5
348	17,424,000	0	0	1	3	2	5
349	17,424,000	0	0	1	2	1	5
350	17,424,000	0	0	1	2	1	5
351	17,424,000	0	0	0	2	1	5
352	17,424,000	0	0	0	2	1	5
353	17,424,000	0	0	0	2	1	5
354	17,424,000	0	0	0	2	1	5
355	17,424,000	0	0	0	2	1	5
356	17,424,000	0	0	0	1	1	5
357	17,424,000	0	0	0	1	1	5
358	17,424,000	0	0	0	1	1	5
359	17,424,000	0	0	0	1	1	5
360	17,424,000	0	0	0	1	1	5
361	17,424,000	0	0	0	1	1	5
362	17,424,000	0	0	0	1	1	5
363	17,424,000	0	0	0	1	1	5
364	17,424,000	0	0	0	1	1	5
365	17,424,000	0	0	0	1	1	5
366	17,424,000	0	0	0	1	1	5
367	17,424,000	0	0	0	1	1	5
368	17,424,000	0	0	0	1	1	5
369	17,424,000	0	0	0	1	1	5
370	17,424,000	0	0	0	1	1	5
371	17,424,000	0	0	0	1	1	5
372	17,424,000	0	0	0	0	1	5

373	17,424,000	0	0	0	0	1	5
Max						1,137	
Avg						732	

Appendix C
RDF Facility Case Study

RDF CASE STUDY

A recent example of a North American RDF facility (producing pellets) is the Dongara Pellet Factory Inc., a facility constructed in the city of Vaughan, Ontario, Canada (Figure C-1). The plant is the end result of an RFP issued in 2003 to handle 70,000 tons of municipal solid waste for the York Region (just north of Toronto). After contract award, the project grew in scope and ultimately encompassed a 20-year contract to receive 100,000 TPY of waste from York Region, with the intent to ramp up to 200,000 tons, some of which will likely come from the surrounding regions.

Figure C-1: Dongara RDF Facility

Generally the facility receives municipal waste from a combination of street and compactor trucks from surrounding transfer stations. Waste is processed to remove recyclables and unwanted residue and hazardous materials. Selected waste is shredded and sent to fiberizing and pelletization equipment. The facility began receiving municipal waste in July 2008.

Residential waste is dropped on the tip floor. Obvious hazardous or large materials are removed to the side for later use or disposal. The remainder is fed into a slow-speed shredder and transferred onto a series of transverse conveyors, where it passes through size-separation trommels, coarse screens, and optical sorting technology to remove PVC plastic, as well as magnets and eddy currents to select and separate ferrous and non-ferrous materials.

The materials suited for fuel pellet production are shredded, fiberized, and stored in storage silos. This material is later combined with high British Thermal Unit (BTU) admixture materials such as carpet waste, poly film, or other acceptable plastic derivatives. The materials are transferred through pellet mills to produce the final fuel pellet, stored, and then transported to end users.

Figure C-2 depicts the RDF produced at the plant.

Figure C-2: Pellets at Dongara Plant

The fuel pellets were originally intended to have an energy content of 10,000–12,000 BTU/lb, with a density of approximately 40–45 lbs/cubic foot and moisture content no greater than 8%. Dongara says these qualities make their fuel pellet competitive with coal in energy content, with much cleaner chemistry. To-date the facility has not been able to achieve these BTU values from a mixed municipal waste stream and the chemistry of the pellets has affected the quality of the combustion air emissions. The typical BTU value being achieved by the company has not been made available.

Originally, it was intended that the facility would ultimately be capable of processing approximately 200,000 TPY and the company initially contracted with a municipality to process 100,000 TPY. The facility has only been able to process approximately 75,000 TPY due to the issues identified above plus the facility has not been able to successfully remove all of the metals in the waste stream. Any pellets containing traces of metals are rejected. Consequently the process has been focused on improving the quality of the feedstock received.

Production statistics to date indicate the following:

Material	Low Recovery %	High Recovery %	Average Recovery %
Oversized/unacceptable materials	15	15	15
Moisture Loss	10	5	7.5
Residue	40	45	42.5
Recyclables	10	5	7.5
Pellets	25	30	27.5
Total	100		100

Using the average recovery data noted above, the facility on average produces the following operating at 75,000 TPY:

Material	Average Recovery %	Tons of Each Material at 75,000 TPY
Oversized/Unacceptable Materials	15	11,250
Moisture Loss	7.5	5,625
Residue	42.5	31,875
Recyclables	7.5	5,625
Pellets	27.5	20,625
Total	100	75,000

In other words, of the 75,000 tons of inbound material, only 35% or 26,250 TPY have been diverted.

The facility costs $50 million to construct. The Contractor's operating costs are not known. The Region of York pays Dongara as follows (based on 75,000 metric tons inbound and the average recovery data noted above):

- $88.02/ton × 75,000 tons= $6,601,500/year
- $121.10/ton of unacceptable/oversized non-processable materials – 11,250 tons = $1,362,375/year
- Total = $7,963,875 year or $8 million

Dongara pays for all costs associated with the disposal of residue (and retains any/all cost/revenue from the sale of the pellets or recyclables.

Appendix D
Projected Traffic Generation

Appendix D - Estimated Traffic Count by RRP Waste Management Initative – Kaua'i Resource Recovery Park Feasibility Study

Table D-1: Inbound Vehicles Loose Materials and Employees

RRP Waste Management Initiative	Comment: Material Description/ Other Assumptions	Tons of Material/ Year	Vehicle Assumptions: Type of Vehicle	Vehicle Assumptions: Comment	Assumed Payload Tons/ Vehicle	No. of Employees	Inbound Vehicles/ Year	Inbound Vehicles/ Month	Inbound Vehicles/ Day (260 days/yr)
1. Integrated Drop-off Facility	Reference facility processed 29,582 vehicles/year serving population of approx. 300,000. Assume that the County's facility will process 20% of that or 6,000 vehicles/year.	250	Personal Vehicle	50% of the total Drop-off material is delivered in personal vehicles by residential generators and assume that each of these vehicles brings in on average 75 lbs.	0.0375		6,667	556	26
		250	Small truck	50% of the total Drop-off material is delivered in small trucks by small commercial generators and assume payload of 500 lbs.	0.2500		1,000	83	4
	Employees	-	Personal Vehicle	2 scale operators, 2 HHW operators, 1–2 truck drivers, 1 subforeman, 1 foreman, and 3–4 platform laborers.	-	12	3,120	260	12
	Total Integrated Drop-off Facility Materials Managed (TPY)	***500***		***Total Integrated Drop-off Facility Vehicles***			***10,787***	***899***	***41***
5. Metals Recycling Facility	9,681 white good units per year at an average weight of 175 lbs each.	968	Roll-off Truck	60% of the total scrap metal material is delivered in roll-off trucks.	5		356	30	1.4
	Other miscellaneous scrap metal items	2,000	Tractor Trailer	30% of the total scrap metal material is delivered in tractor trailers.	20		45	4	0.2
			Pick-up Truck	10% of the total scrap metal material is delivered in pick-up trucks.	0.5		594	49	2.3
	Employees	-	Personal Vehicle	Drop-off area employees included in 1. Integrated Drop-off Facility. Scrap metal processing line: 2 full-time staff.	-	2	520	43	2
	Total Scrap Metal Managed (TPY)	***2,968***		***Total Scrap Metal Vehicles***			***1,514***	***126***	***6***
6. Construction and Demolition (C&D) Facility	Construction and Demolition Material	20,000	Various	70% of the total C&D is delivered in roll-off trucks.	5		2,800	233	11
				20% of the total C&D is delivered in stake trucks.	3		1,333	111	5
				10% of the total C&D is delivered in small dump trucks.	1		2,000	167	8
	Employees	-	Personal Vehicle	14 full-time staff.	-	14	3,640	303	14
	Total C&D Managed (TPY)	***20,000***		***Total C&D Vehicles***			***9,773***	***814***	***38***
[6.] Concrete and Asphalt Crushing & Screening	Concrete and Asphalt Material	5,000	Roll-off Truck	100% of the total Concrete and Asphalt is delivered in roll-off trucks.	5		1,000	83	4
	Employees	-	Personal Vehicle	4 full-time staff.	-	4	1,040	87	4
	Total Concrete & Asphalt Managed (TPY)	***5,000***		***Total Concrete & Asphalt Vehicles***			***2,040***	***170***	***8***
7. Used Tire Processing System	Assume 80,000 tires/year. Passenger tires compose 80% of annual tire generation and weigh 22 lbs each.	704	Tractor Trailer	60% of the total scrap tires are delivered in tractor trailers.	20		31	3	0.12
	Assume 80,000 tires/year. Small trucks compose 10% of annual tire generation and weigh 35 lbs each.	140	Roll-off Truck	20% of the total scrap tires are delivered in roll-off trucks.	5		42	3	0.16
	Assume 80,000 tires/year. Large tires compose 10% of annual tire generation and weigh 50 lbs each.	200	Personal Vehicle	20% of the total scrap tires are delivered in personal vehicles.	0.075		2,784	232	10.7
	Employees	-	Personal Vehicle	Drop-off area employees included in 1. Integrated Drop-off Facility. Scrap metal processing line: 2 full-time staff.	-	4	1,040	87	4
	Total Scrap Tires Managed (TPY)	***1,044***		***Total Scrap Tire Vehicles***			***3,897***	***325***	***15***

Table D-1: Inbound Vehicles (cont.)

RRP Waste Management Initiative	Comment: Material Description/ Other Assumptions	Comment: Tons of Material/ Year	Vehicle Assumptions: Type of Vehicle	Vehicle Assumptions: Comment	Vehicle Assumptions: Assumed Payload Tons/ Vehicle	No. of Employees	Inbound Vehicles/ Year	Inbound Vehicles/ Month	Inbound Vehicles/ Day (260 days/yr)
11. Single Stream Material Recovery Facility (MRF)	Residental Recyclables	12,418	Recycling Truck	100% of the Residential Recyclables are delivered in curbside recycling trucks.	5		2,484	207	10
	Commercial Recyclables	14,265	Roll-off Truck	50% of the total Commercial Recyclable material is delivered in roll-off trucks.	5		1,427	119	5
			Front-end Truck	50% of Commercial Recyclable Materials is delivered in front-end trucks.	5		1,427	119	5
	Employees	-	Personal Vehicle	1 facility manager, 1 receptionist/ materials sales, 1 supervisor/mechanic, 1 scale house operator, 1 equipment operator, 10 sorters (2 on pre-sort, 2 on fiber line, 6 on container line).	-	15	3,900	325	15
	Total MRF Materials Managed (TPY)	***26,683***				***Total MRF Vehicles***	***9,237***	***770***	***36***
12. Compost Facility	Organic Material	33,812	Rear Packer & Roll-off Trucks	60% of the total compost material is delivered in rear-packer trucks.	5		4,057	338	16
			Pick-up Truck	30% of the total compost material is delivered in pick-up trucks.	0.5		20,287	1,691	78
			Personal Vehicle	10% of the total compost material is delivered in personal vehicle.	0.1		33,812	2,818	130
	Employees	-	Personal Vehicle	2 site personnel, 2 equipment operators, 1 weighbridge operator.	-	5	1,300	108	5
	Total Compost Materials Managed (TPY)	***33,812***				***Total Compost Vehicles***	***59,457***	***4,955***	***229***
13. Anaerobic Digestion (AD)	Biosolids & Commercial Food Waste	5,063	Rear Packer Truck	60% of the total AD material is delivered in rear-packer trucks.	5		608	51	2
			Pick-up Truck	30% of the total AD material is delivered in small trucks.	0.5		3,038	253	12
			Personal Vehicle	10% of the total AD material is delivered in personal vehicles.	0.1		5,063	422	19
	Employees	-	Personal Vehicle	8 full-time equivalent staff.	-	8	2,080	173	8.0
	Total AD Materials Managed (TPY)	***5,063***				***Total AD Vehicles***	***10,788***	***899***	***41***
16. Waste to Energy Facility	Garbage	100,000	Garbage Truck	100% of the total garbage is delivered in garbage trucks.	10		10,000	833	38
	Employees	-	Personal Vehicle	20 full-time staff (two 12-hr shifts 365 days/year); additional support staff on an as-needed basis.	-	40	14,600	1,217	40
	Total Waste to Energy Materials Managed (TPY)	***100,000***				***Total Waste to Energy Vehicles***	***24,600***	***2,050***	***78***

Appendix D - Estimated Traffic Count by RRP Waste Management Initative – Kaua'i Resource Recovery Park Feasibility Study

Table D-2: Outbound Vehicles Consolidated Materials and Employees

RRP Waste Management Initiative	Comment: Material Description/ Other Assumptions	Comment: Tons of Material/ Year	Vehicle Assumptions: Type of Vehicle	Vehicle Assumptions: Comment	Vehicle Assumptions: Assumed Payload Tons/ Vehicle	No. of Employees	Outbound Vehicles/ Year	Outbound Vehicles/ Month	Outbound Vehicles/ Day (260 days/yr)
1. Integrated Drop-off Facility		500	Roll-off Truck	100% of the total integrated drop-off material leaves in roll-off trucks.	5		100	8	0.4
	Employees	-	Personal Vehicle	2 scale operators, 2 HHW operators, 1–2 truck drivers, 1 subforeman, 1 foreman, and 3–4 platform laborers.	-	12	3,120	260	12
	Total Integrated Drop-off Facility Managed (TPY)	***500***		***Total Integrated Drop-off Facility Vehicles***			***3,220***	***268***	***12***
5. Metals Recycling Facility	Assume all scrap metal goes out baled.	2,968	Tractor Trailer	100% of the total scrap metal material leaves in transfer trailers.	20		148	12	0.6
	Employees	-	Personal Vehicle	Drop-off area employees included in 1. Integrated Drop-off Facility. Scrap metal processing line: 2 full-time staff.	-	2	520	43	2
	Total Scrap Metal Managed (TPY)	***2,968***		***Total Scrap Metal Vehicles***			***668***	***56***	***3***
6. Construction and Demolition (C&D) Facility	Construction and Demolition Material	20,000	Tractor Trailer	60% of the total C&D goes out in tractor trailers.	20		600	50	2
			Roll-off Truck	20% of the total C&D goes out in roll-off trucks.	10		400	33	2
			Roll-off Truck	20% of the total C&D goes out in roll-off trucks.	5		800	67	3
	Employees	-	Personal Vehicle	14 full-time staff.	-	14	3,640	303	14
	Total C&D Materials Managed (TPY)	***20,000***		***Total C&D Vehicles***			***5,440***	***453***	***21***
[6.] Concrete and Asphalt Crushing & Screening	Assume all concrete and asphalt leaves in tractor trailers.	5,000	Tractor Trailer	100% of the total Concrete and Asphalt leaves in tractor trailer.	20		250	21	1
	Employees	-	Personal Vehicle	4 full-time staff.	-	4	1,040	87	4
	Total Concrete and Asphalt Managed (TPY)	***5,000***		***Total Concrete and Asphalt Vehicles***			***1,290***	***108***	***5***
7. Used Tire Processing System	Assume all baled scrap tires leave in tractor trailers.	1,044	Tractor Trailer	100% of the total scrap tires leaves in tractor trailer.	20		52	4	0
	Employees	-	Personal Vehicle	Drop-off area employees included in 1. Integrated Drop-off Facility. Scrap metal processing line: 2 full-time staff.	-	4	1,040	87	4
	Total Scrap Tires Managed (TPY)	***1,044***		***Total Scrap Tire Vehicles***			***1,092***	***91***	***4***
11. Single Stream Material Recovery Facility (MRF)	Residental and Commercial Waste	26,683	Tractor Trailer	100% of the total residential and commercial waste leaves in transfer trailers.	20		1,334	111	5
	Employees	-	Personal Vehicle	1 facility manager, 1 receptionist/ materials sales, 1 supervisor/mechanic, 1 scale house operator, 1 equipment operator, 10 sorters (2 on pre-sort, 2 on fiber line, 6 on container line).	-	15	3,900	325	15
	Total MRF Materials Managed (TPY)	***26,683***		***Total MRF Vehicles***			***5,234***	***436***	***20***
12. Compost Facility	After decomposition, the composted material is reduced down to 70% due to water lose and mass reduction.	23,668	Tractor Trailer	100% of the total compost material leaves in transfer trailers.	20		1,183	99	5
	Employees	-	Personal Vehicle	2 site personnel, 2 equipment operators, 1 weighbridge operator.	-	5	1,300	108	5
	Total Compost Materials Managed (TPY)	***23,668***		***Total Compost Vehicles***			***2,483***	***207***	***10***

Table D-2 Outbound Vehicles (cont.)

RRP Waste Management Initiative	Comment		Vehicle Assumptions				Outbound Vehicles/ Year	Outbound Vehicles/ Month	Outbound Vehicles/ Day (260 days/yr)
	Material Description/ Other Assumptions	Tons of Material/ Year	Type of Vehicle	Comment	Assumed Payload Tons/ Vehicle	No. of Employees			
13. Anaerobic Digestion (AD) Facility	After decomposition, the AD digested material is reduced down to 70% due to water lose and mass reduction.	3,544	Tractor Trailer	100% of the total AD material leaves in transfer trailers.	20		177	15	1
	Employees	-	Personal Vehicle	8 full-time equivalent staff.	-	8	2,080	173	8.0
	Total AD Materials Managed (TPY)	***3,544***		***Total AD Vehicles***			***177***	***15***	***1***
16. Waste to Energy Facility	25,000 goes out as ash in tractor trailers.	25,000	Tractor Trailer	100% of the total Waste to Energy material leaves in tractor trailer.	20		1,250	104	5
	Employees	-	Personal Vehicle	20 full-time staff (two 12-hr shifts 365 days/year); additional support staff on an as-needed basis.	-	40	14,600	1,217	40
	Total Waste to Energy Material Managed (TPY)	***25,000***		***Total Waste to Energy Vehicles***			***15,850***	***1,321***	***45***

Appendix D - Estimated Traffic Count by RRP Waste Management Initative – Kaua'i Resource Recovery Park Feasibility Study

Table D-3: Total Inbound & Outbound Vehicle Count by RRP Waste Management Initiative

RRP Waste Management Initiative	Comment: Material Description/ Other Assumptions	Comment: Tons of Material/ Year	Vehicle Assumptions: Type of Vehicle	Vehicle Assumptions: Comment	Vehicle Assumptions: Assumed Payload Tons/ Vehicle	No. of Employees	In & Outbound Vehicles/ Year	In & Outbound Vehicles/ Month	In & Outbound Vehicles/ Day (260 days/yr)
1. Integrated Drop-off Facility	Various Materials	-	Personal Vehicle	Inbound	0.04		6,667	556	26
				Outbound			6,667	556	26
			Small truck	Inbound	0.25		1,000	83	4
				Outbound			1,000	83	4
			Roll-off Truck	Outbound	5		100	8	0.4
				Inbound			100	8	0.4
			Personal Vehicle	Inbound Employee		12	3,120	260	12
				Outbound Employee		12	3,120	260	12
				Total Integrated Drop-off Vehicles IN and OUT			***21,773***	***1,814***	***84***
5. Metals Recycling Facility	Scrap Metal Material	-	Roll-off Truck	Inbound	5		356	30	1.4
				Outbound			356	30	1.4
			Small Truck	Inbound	0.5		594	49	2.3
				Outbound			594	49	2.3
			Tractor Trailer	Inbound	20		45	4	0.2
				Outbound			45	4	0.2
			Tractor Trailer	Outbound	20		148	12	1
				Inbound			148	12	1
			Personal Vehicle	Inbound Employee		2	520	43	2
				Outbound Employee		2	520	43	2
				Total Scrap Metal Vehicles IN and OUT			***3,325***	***277***	***13***
6. Construction and Demolition (C&D) Facility	Constrution and Demolition (C&D) Material	-	Roll-off Truck	Inbound	5		2,800	233	11
				Outbound			2,800	233	11
			Stake Truck	Inbound	3		1,333	111	5
				Outbound			1,333	111	5
			Small truck	Inbound	1		2,000	8	8
				Outbound			2,000	8	8
			Tractor Trailer	Outbound	20		600	50	2
				Inbound			600	50	2
			Roll-off Truck	Outbound	10		400	33	2
				Inbound			400	33	2
			Roll-off Truck	Outbound	5		800	67	3
				Inbound			800	67	3
			Personal Vehicle	Inbound Employee		14	3,640	303	14
				Outbound Employee		14	3,640	303	14
				Total C&D Vehicles IN and OUT			***23,147***	***1,611***	***89***
[6.] Concrete and Asphalt Crushing & Screening	Concrete and Asphalt Material	-	Roll-off Truck	Inbound	5		1,000	83	4
				Outbound			1,000	83	4
			Tractor Trailer	Outbound	20		250	21	1
				Inbound			250	21	1
			Personal Vehicle	Inbound Employee		4	1,040	87	4
				Outbound Employee		4	1,040	87	4
				Total Concrete and Ashpalt Vehicles IN and OUT			***4,580***	***382***	***18***
7. Used Tire Processing System	Scrap Tires	-	Tractor Trailer	Inbound	20		31	3	0
				Outbound			31	3	0
			Roll-off Truck	Inbound	5		42	3	0
				Outbound			42	3	0
			Personal Vehicle	Inbound	0.075		2,784	232	11
				Outbound			2,784	232	11
			Tractor Trailer	Outbound	20		52	4	0
				Inbound			52	4	0
			Personal Vehicle	Inbound Employee		4	1,040	87	4
				Outbound Employee		4	1,040	87	4
				Total Scrap Tires Vehicles IN and OUT			***7,899***	***658***	***30***

Table D-3 Inbound & Outbound Vehicles (cont.)

RRP Waste Management Initiative	Comment: Material Description/ Other Assumptions	Comment: Tons of Material/ Year	Vehicle Assumptions: Type of Vehicle	Vehicle Assumptions: Comment	Vehicle Assumptions: Assumed Payload Tons/ Vehicle	No. of Employees	In & Outbound Vehicles/ Year	In & Outbound Vehicles/ Month	In & Outbound Vehicles/ Day (260 days/yr)
11. Single Stream Material Recovery Facility (MRF)	Residental and Commercial Recyclabes	-	Recycling Truck	Inbound	5		2,484	207	10
				Outbound			2,484	207	10
			Roll-off Truck	Inbound	5		1,427	119	5
				Outbound			1,427	119	5
			Front-end Truck	Inbound	5		1,427	119	5
				Outbound			1,427	119	5
			Tractor Trailer	Outbound	20		1,334	111	5
				Inbound			1,334	111	5
			Personal Vehicle	Inbound Employee		15	3,900	325	15
				Outbound Employee		15	3,900	325	15
			Total MRF Vehicles IN and OUT				***21,142***	***1,762***	***81***
12. Compost Facility	Organic Material	10,144	Rear Packer & Roll-off Trucks	Inbound	5		4,057	338	16
				Outbound			4,057	338	16
			Small Truck	Inbound	0.5		20,287	1,691	78
				Outbound			20,287	1,691	78
			Personal Vehicle	Inbound	0.1		33,812	2,818	130
				Outbound			33,812	2,818	130
			Tractor Trailer	Outbound	20		1,183	99	5
				Inbound			1,183	99	5
			Personal Vehicle	Inbound Employee		5	1,300	108	5
				Outbound Employee		5	1,300	108	5
			Total Compost Vehicles IN and OUT				***121,280***	***10,107***	***466***
13. Anaerobic Digestion (AD) Facility	Commercial Food & Biosolids	1,519	Rear Packer Truck	Inbound	5		608	51	2
				Outbound			608	51	2
			Small Truck	Inbound	0.5		3,038	253	12
				Outbound			3,038	253	12
			Personal Vehicle	Inbound	0.1		5,063	422	19
				Outbound			5,063	422	19
			Tractor Trailer	Outbound	20		177	15	1
				Inbound			177	15	1
			Personal Vehicle	Inbound Employee		8	2,080	173	8
				Outbound Employee		8	2,080	173	8
			Total AD Vehicles IN and OUT				***21,931***	***1,828***	***84***
16. Waste to Energy Facility	Waste to Energy Material		Garbage Truck	Inbound	10		10,000	833	38
				Outbound			10,000	833	38
			Tractor Trailer	Outbound	20		1,250	104	5
				Inbound			1,250	104	5
			Personal Vehicle	Inbound Employee		40	14,600	1,217	40
				Outbound Employee		40	14,600	1,217	40
			Total Waste to Energy Vehicles IN and OUT				***51,700***	***4,308***	***167***

Appendix E
Projected Revenues per Ton of Diverted Waste by Facility

PROJECTED REVENUES PER TON OF DIVERTED WASTE PER FACILITY

This appendix provides projected estimates of the revenues and costs for each feasible RRP facility, on a per ton basis. These estimates are based on the waste recovery projections over the 20 year planning period, as developed in Section 3 of the main report. The projected diversion rate at each of the feasible RRP facilities and capital and operation & maintenance (O&M) costs for each of the recommended RRP facilities are presented in Section 4 of the main report. For those recyclable materials with a market value, commodity prices are taken to be the 2012 values, as presented in Section 2 of the main report.

Revenue projections are based on the high (aggressive) recovery estimates presented in the report. Consequently, if diversion estimates are not achieved, revenues may decrease accordingly. Recyclable commodity prices have historically been highly variable with wide fluctuations in value; however, prices have been held constant in this projection, which may result in conservative estimates of potential future revenues.

Since they are based on estimates of diversion quantities, capital and O&M costs, and fluctuating commodity prices, the projected revenues per ton presented in this appendix should be considered planning-level estimates.

Tables E-1 through E-8 display the development of the forecasted costs and revenues estimates for the recommended RRP facilities, which are summarized in Table 37 of the main body of this report. Each of the columns for the tables is described below.

> **# Years:** This column specifies the number of years from the baseline date, end of year 2012. The baseline date established is end of year 2012 because initial estimates for capital costs, operating and maintenance costs, and gross revenues are based on purchasing power of currency at this date. The baseline financials indicate costs and revenues that would be expected if the RRP facilities to be constructed and operational on the baseline date.
>
> **End of Year:** This column sets out the various dates over the lifespan of the RRP project.
>
> **Annual depreciation (capital assets):** This column sets out forecasted depreciation of capital assets over the lifespan the RRP facilities. Annual depreciation is determined by dividing the value of capital assets for developing the RRP facilities on the launch date by the number of years encompassing the planning period of the RRP facilities (20 years). Depreciation of capital assets is linear.
>
> **Capital Asset Value:** This column sets out forecasted annual value of capital assets utilized for the RRP facilities. Baseline asset values are adjusted to account for annual inflation leading up to the target launch date of end of year 2016. Baseline capital costs were inflated using the formula, $CCb*(1+r)^{Yn}$, where CCb represents the baseline capital cost, r represents the inflation rate, and Y represents the number of years from baseline date. Subsequent to the launch date depreciation is deducted annually from the value of capital assets at a linear rate. The value of capital assets at the end of the lifespan of the project is calculated as zero. The estimated Capital Asset Value for each facility is described in the appropriate sub-section within Section 4 of the main body of this report.
>
> **Inflation:** This column sets out forecast inflation rate of currency of 2% for each year.
>
> **O&M Costs:** This column sets out forecasted annual operation and maintenance costs. Baseline estimates of operation and maintenance costs were adjusted to account for inflation using the formula, $OMb*(1+r)^{Y}$, where OMb represents the baseline operating and maintenance costs. The estimated O&M Costs for each facility is described in the appropriate sub-section of Section 4 of the main body of this report.

Gross Revenue: This column sets out forecast annual gross revenue. Baseline estimates of gross revenue were adjusted to account for inflation using the formula, $T*Rb*(1+r)^Y$, where T represents the number of tons diverted, and Rb represents the baseline estimate of gross revenue per ton of waste diverted. Gross Revenues have been identified for the Materials Recycling and Metals Recycling facilities based on estimated commodity values.

For the MRF, current commodity prices shown in Table 2 of the report were applied to estimated tons of recyclables recovered by material type. Revenues for Low and High estimates of recyclables recovered, based on Tables 13 and 16 in the report, were calculated. Table E-9 provides a sensitivity analysis of how potential revenues by commodity type managed through the MRF can be influenced by the level of diversion achieved in the future. As shown in Table E-9, revenues of $95 per ton are estimated for the basket of recyclable commodities diverted through the MRF. The MRF revenue estimates shown in Table E-5 are based on the High estimate for recyclables recovery by 2037.

Revenues of $115 per ton were assumed for the scrap metal recovered based on current market prices in Hawaii, as available from Schnitzer Steel. Gross revenues for landfill gas to energy and waste to energy are as estimated in Section 4 of the main body of the report.

Tons Diverted: This column sets out the forecasted annual number of tons to be diverted by the RRP facility. The tons diverted for each facility are based on the estimates provided in Section 4 of the main body of the report. For the purposes of this analysis, diverted tons through the Integrated Public Drop-off and Reuse Facility, Metals Recycling, Construction and Demolition Waste, Used Tires, and Waste to Energy facilities were held constant through the planning period. For the Material Recovery Facility, tons of waste diverted were assumed to increase from minimum recovery levels in the first year to maximum recovery levels within 10 years. These estimates were developed in Chapter 3 of the main report (see Tables 10, 13 and 16) and also presented in Section 4.11. Similarly, for the Composting Facility, tons diverted were assumed to increase between the first and twentieth year as projected in Chapter 3 of the main report (see Table 24) and presented in Section 4.12.

Tons Diverted as % of total: This column expresses the forecasted annual number of tons of waste to be diverted by the RRP facility as a per cent of total waste diverted.

Net Revenue: This column sets out forecasted net revenue over the lifespan of the RRP facilities. Net revenue is determined by deducting operating and maintenance costs and annual depreciation from gross revenue.

Net Revenue per Ton: This column sets out forecasted net revenue per ton over the lifespan of the RRP facilities. Net revenue is calculated by deducting operating and maintenance costs and annual depreciation from gross revenue.

Table E-1: Integrated Public Drop-off and Reuse Facility Revenue and Cost Estimate

# Years	End of Year	Annual Depreciation on (Capital Assets)	Capital Asset Value	Inflation (%)	O&M Costs	Tons Diverted	Tons Diverted as % of Total	Gross Revenue	Net Revenue	Net Revenue per Ton
0	2012	$ -	$8,900,000	0%	$2,330,000	-	-	-	-	-
1	2013	$ -	$9,078,000	2%	$2,376,600	-	-	-	-	-
2	2014	$ -	$9,259,560	2%	$2,424,132	-	-	-	-	-
3	2015	$ -	$9,444,751	2%	$2,472,615	-	-	-	-	-
4	2016	$ -	$9,633,646	2%	$2,522,067	-	-	-	-	-
5	2017	$ -	$9,151,964	2%	$2,572,508	12,840	8.7%	$ -	$ (3,054,191)	$ (237.87)
6	2018	$ -	$8,670,282	2%	$2,623,958	12,840	8.7%	$ -	$ (3,105,641)	$ (241.87)
7	2019	$481,682	$8,188,599	2%	$2,676,438	12,840	8.7%	$ -	$ (3,158,120)	$ (245.96)
8	2020	$481,682	$7,706,917	2%	$2,729,966	12,840	8.7%	$ -	$ (3,211,649)	$ (250.13)
9	2021	$481,682	$7,225,235	2%	$2,784,566	12,840	8.7%	$ -	$ (3,266,248)	$ (254.38)
10	2022	$481,682	$6,743,552	2%	$2,840,257	12,840	8.7%	$ -	$ (3,321,939)	$ (258.72)
11	2023	$481,682	$6,261,870	2%	$2,897,062	12,840	8.7%	$ -	$ (3,378,744)	$ (263.14)
12	2024	$481,682	$5,780,188	2%	$2,955,003	12,840	8.7%	$ -	$ (3,436,686)	$ (267.65)
13	2025	$481,682	$5,298,505	2%	$3,014,103	12,840	8.7%	$ -	$ (3,495,786)	$ (272.26)
14	2026	$481,682	$4,816,823	2%	$3,074,386	12,840	8.7%	$ -	$ (3,556,068)	$ (276.95)
15	2027	$481,682	$4,335,141	2%	$3,135,873	12,840	8.7%	$ -	$ (3,617,556)	$ (281.74)
16	2028	$481,682	$3,853,458	2%	$3,198,591	12,840	8.7%	$ -	$ (3,680,273)	$ (286.63)
17	2029	$481,682	$3,371,776	2%	$3,262,563	12,840	8.7%	$ -	$ (3,744,245)	$ (291.61)
18	2030	$481,682	$2,890,094	2%	$3,327,814	12,840	8.7%	$ -	$ (3,809,496)	$ (296.69)
19	2031	$481,682	$2,408,412	2%	$3,394,370	12,840	8.7%	$ -	$ (3,876,052)	$ (301.87)
20	2032	$481,682	$1,926,729	2%	$3,462,257	12,840	8.7%	$ -	$ (3,943,940)	$ (307.16)
21	2033	$481,682	$1,445,047	2%	$3,531,503	12,840	8.7%	$ -	$ (4,013,185)	$ (312.55)
22	2034	$481,682	$963,365	2%	$3,602,133	12,840	8.7%	$ -	$ (4,083,815)	$ (318.05)
23	2035	$481,682	$481,682	2%	$3,674,175	12,840	8.7%	$ -	$ (4,155,858)	$ (323.66)
24	2036	$481,682	$(0)	2%	$3,747,659	12,840	8.7%	$ -	$ (4,229,341)	$ (329.39)

Table E-2: Metals Recycling Facility Revenue and Cost Estimate

# Years	End of Year	Annual Depreciation on (Capital Assets)	Capital Asset Value	Inflation (%)	O&M Costs	Tons Diverted	Tons Diverted as % of Total	Gross Revenue	Net Revenue	Net Revenue per Ton
0	2012	$ -	$2,000,000	0%	$560,000	4,700	-	$540,500	-	-
1	2013	$ -	$2,040,000	2%	$571,200	4,700	-	$551,310	-	-
2	2014	$ -	$2,080,800	2%	$582,624	4,700	-	$562,336	-	-
3	2015	$ -	$2,122,416	2%	$594,276	4,700	-	$573,583	-	-
4	2016	$ -	$2,164,864	2%	$606,162	4,700	-	$585,055	-	-
5	2017	$108,243	$2,056,621	2%	$618,285	4,700	3.2%	$596,756	$ (129,773)	$ (27.61)
6	2018	$108,243	$1,948,378	2%	$630,651	4,700	3.2%	$608,691	$ (130,203)	$ (27.70)
7	2019	$108,243	$1,840,135	2%	$643,264	4,700	3.2%	$620,865	$ (130,643)	$ (27.80)
8	2020	$108,243	$1,731,891	2%	$656,129	4,700	3.2%	$633,282	$ (131,091)	$ (27.89)
9	2021	$108,243	$1,623,648	2%	$669,252	4,700	3.2%	$645,948	$ (131,548)	$ (27.99)
10	2022	$108,243	$1,515,405	2%	$682,637	4,700	3.2%	$658,866	$ (132,014)	$ (28.09)
11	2023	$108,243	$1,407,162	2%	$696,290	4,700	3.2%	$672,044	$ (132,489)	$ (28.19)
12	2024	$108,243	$1,298,919	2%	$710,215	4,700	3.2%	$685,485	$ (132,974)	$ (28.29)
13	2025	$108,243	$1,190,675	2%	$724,420	4,700	3.2%	$699,194	$ (133,469)	$ (28.40)
14	2026	$108,243	$1,082,432	2%	$738,908	4,700	3.2%	$713,178	$ (133,973)	$ (28.50)
15	2027	$108,243	$974,189	2%	$753,686	4,700	3.2%	$727,442	$ (134,488)	$ (28.61)
16	2028	$108,243	$865,946	2%	$768,760	4,700	3.2%	$741,991	$ (135,013)	$ (28.73)
17	2029	$108,243	$757,703	2%	$784,135	4,700	3.2%	$756,830	$ (135,548)	$ (28.84)
18	2030	$108,243	$649,459	2%	$799,818	4,700	3.2%	$771,967	$ (136,094)	$ (28.96)
19	2031	$108,243	$541,216	2%	$815,814	4,700	3.2%	$787,406	$ (136,651)	$ (29.07)
20	2032	$108,243	$432,973	2%	$832,131	4,700	3.2%	$803,155	$ (137,219)	$ (29.20)
21	2033	$108,243	$324,730	2%	$848,773	4,700	3.2%	$819,218	$ (137,799)	$ (29.32)
22	2034	$108,243	$216,486	2%	$865,749	4,700	3.2%	$835,602	$ (138,390)	$ (29.44)
23	2035	$108,243	$108,243	2%	$883,064	4,700	3.2%	$852,314	$ (138,993)	$ (29.57)
24	2036	$108,243	$ (0)	2%	$900,725	4,700	3.2%	$869,360	$ (139,608)	$ (29.70)

Table E-3: Construction and Demolition Material Facility Revenue and Cost Estimate

# Years	End of Year	Annual Depreciation on (Capital Assets)	Capital Asset Value	Inflation (%)	O&M Costs	Tons Diverted	Tons Diverted as % of Total	Gross Revenue	Net Revenue	Net Revenue per Ton
0	2012	$ -	$1,430,000	0%	$870,000	9,000	6.1%	$ -	-	-
1	2013	$ -	$1,458,600	2%	$887,400	9,000	6.1%	$ -	-	-
2	2014	$ -	$1,487,772	2%	$905,148	9,000	6.1%	$ -	-	-
3	2015	$ -	$1,517,527	2%	$923,251	9,000	6.1%	$ -	-	-
4	2016	$ -	$1,547,878	2%	$941,716	9,000	6.1%	$ -	-	-
5	2017	$77,394	$1,470,484	2%	$960,550	9,000	6.1%	$ -	$ (1,037,944)	$ (115.33)
6	2018	$77,394	$1,393,090	2%	$979,761	9,000	6.1%	$ -	$ (1,057,155)	$ (117.46)
7	2019	$77,394	$1,315,696	2%	$999,357	9,000	6.1%	$ -	$ (1,076,750)	$ (119.64)
8	2020	$77,394	$1,238,302	2%	$1,019,344	9,000	6.1%	$ -	$ (1,096,738)	$ (121.86)
9	2021	$77,394	$1,160,908	2%	$1,039,731	9,000	6.1%	$ -	$ (1,117,124)	$ (124.12)
10	2022	$77,394	$1,083,515	2%	$1,060,525	9,000	6.1%	$ -	$ (1,137,919)	$ (126.44)
11	2023	$77,394	$1,006,121	2%	$1,081,736	9,000	6.1%	$ -	$ (1,159,130)	$ (128.79)
12	2024	$77,393.90	$928,727	2%	$1,103,370	9,000	6.1%	$ -	$ (1,180,764)	$ (131.20)
13	2025	$77,394	$851,333	2%	$1,125,438	9,000	6.1%	$ -	$ (1,202,832)	$ (133.65)
14	2026	$77,394	$773,939	2%	$1,147,947	9,000	6.1%	$ -	$ (1,225,340)	$ (136.15)
15	2027	$77,394	$696,545	2%	$1,170,905	9,000	6.1%	$ -	$ (1,248,299)	$ (138.70)
16	2028	$77,394	$619,151	2%	$1,194,324	9,000	6.1%	$ -	$ (1,271,717)	$ (141.30)
17	2029	$77,394	$541,757	2%	$1,218,210	9,000	6.1%	$ -	$ (1,295,604)	$ (143.96)
18	2030	$77,394	$464,363	2%	$1,242,574	9,000	6.1%	$ -	$ (1,319,968)	$ (146.66)
19	2031	$77,394	$386,969	2%	$1,267,426	9,000	6.1%	$ -	$ (1,344,820)	$ (149.42)
20	2032	$77,394	$309,576	2%	$1,292,774	9,000	6.1%	$ -	$ (1,370,168)	$ (152.24)
21	2033	$77,394	$232,182	2%	$1,318,630	9,000	6.1%	$ -	$ (1,396,024)	$ (155.11)
22	2034	$77,394	$154,788	2%	$1,345,002	9,000	6.1%	$ -	$ (1,422,396)	$ (158.04)
23	2035	$77,394	$77,394	2%	$1,371,902	9,000	6.1%	$ -	$ (1,449,296)	$ (161.03)
24	2036	$77,394	$ (0)	2%	$1,399,340	9,000	6.1%	$ -	$ (1,476,734)	$ (164.08)

Table E-4: Used Tire Processing Facility Revenue and Cost Estimate

# Years	End of Year	Annual Depreciation on (Capital Assets)	Capital Asset Value	Inflation (%)	O&M Costs	Tons Diverted	Tons Diverted as % of Total	Gross Revenue	Net Revenue	Net Revenue per Ton
0	2012	$ -	$252,000	0%	$165,000	1,482	1.0%	$ -	-	-
1	2013	$ -	$257,040	2%	$168,300	1,482	1.0%	$ -	-	-
2	2014	$ -	$262,181	2%	$171,666	1,482	1.0%	$ -	-	-
3	2015	$ -	$267,424	2%	$175,099	1,482	1.0%	$ -	-	-
4	2016	$ -	$272,773	2%	$178,601	1,482	1.0%	$ -	-	-
5	2017	$13,639	$259,134	2%	$182,173	1,482	1.0%	$ -	$ (195,812)	$ (132.13)
6	2018	$13,639	$245,496	2%	$185,817	1,482	1.0%	$ -	$ (199,455)	$ (134.59)
7	2019	$13,639	$231,857	2%	$189,533	1,482	1.0%	$ -	$ (203,172)	$ (137.09)
8	2020	$13,639	$218,218	2%	$193,324	1,482	1.0%	$ -	$ (206,962)	$ (139.65)
9	2021	$13,639	$204,580	2%	$197,190	1,482	1.0%	$ -	$ (210,829)	$ (142.26)
10	2022	$13,639	$190,941	2%	$201,134	1,482	1.0%	$ -	$ (214,773)	$ (144.92)
11	2023	$13,639	$177,302	2%	$205,157	1,482	1.0%	$ -	$ (218,795)	$ (147.64)
12	2024	$13,639	$163,664	2%	$209,260	1,482	1.0%	$ -	$ (222,899)	$ (150.40)
13	2025	$13,639	$150,025	2%	$213,445	1,482	1.0%	$ -	$ (227,084)	$ (153.23)
14	2026	$13,639	$136,386	2%	$217,714	1,482	1.0%	$ -	$ (231,353)	$ (156.11)
15	2027	$13,639	$122,748	2%	$222,068	1,482	1.0%	$ -	$ (235,707)	$ (159.05)
16	2028	$13,639	$109,109	2%	$226,510	1,482	1.0%	$ -	$ (240,148)	$ (162.04)
17	2029	$13,639	$95,471	2%	$231,040	1,482	1.0%	$ -	$ (244,678)	$ (165.10)
18	2030	$13,639	$81,832	2%	$235,661	1,482	1.0%	$ -	$ (249,299)	$ (168.22)
19	2031	$13,639	$68,193	2%	$240,374	1,482	1.0%	$ -	$ (254,012)	$ (171.40)
20	2032	$13,639	$54,555	2%	$245,181	1,482	1.0%	$ -	$ (258,820)	$ (174.64)
21	2033	$13,639	$40,916	2%	$250,085	1,482	1.0%	$ -	$ (263,724)	$ (177.95)
22	2034	$13,639	$27,277	2%	$255,087	1,482	1.0%	$ -	$ (268,725)	$ (181.33)
23	2035	$13,639	$13,639	2%	$260,188	1,482	1.0%	$ -	$ (273,827)	$ (184.77)
24	2036	$13,639	$ (0)	2%	$265,392	1,482	1.0%	$ -	$ (279,031)	$ (188.28)

Table E-5: Material Recovery Facility Revenue and Cost Estimate

# Years	End of Year	Annual Depreciation on (Capital Assets)	Capital Asset Value	Inflation (%)	O&M Costs	Tons Diverted	Tons Diverted as % of Total	Gross Revenue	Net Revenue	Net Revenue per Ton
0	2012	$ -	$8,700,000	0%	$950,000	8,209	5.5%	$779,855	-	-
1	2013	$ -	$8,874,000	2%	$969,000	8,209	5.5%	$795,452	-	-
2	2014	$ -	$9,051,480	2%	$988,380	8,209	5.5%	$811,361	-	-
3	2015	$ -	$9,232,510	2%	$1,008,148	8,209	5.5%	$827,588	-	-
4	2016	$ -	$9,417,160	2%	$1,028,311	8,209	5.5%	$844,140	-	-
5	2017	$470,858	$8,946,302	2%	$1,048,877	8,209	5.5%	$861,023	$ (658,712)	$ (80.24)
6	2018	$470,858	$8,475,444	2%	$1,069,854	10,056	6.8%	$1,075,888	$ (464,824)	$ (46.22)
7	2019	$470,858	$8,004,586	2%	$1,091,251	11,904	8.0%	$1,299,004	$ (263,106)	$ (22.10)
8	2020	$470,858	$7,533,728	2%	$1,113,076	13,751	9.3%	$1,530,614	$ (53,321)	$ (3.88)
9	2021	$470,858	$7,062,870	2%	$1,135,338	15,599	10.5%	$1,770,968	$164,772	$10.56
10	2022	$470,858	$6,592,012	2%	$1,158,045	17,446	11.8%	$2,020,325	$391,422	$22.44
11	2023	$470,858	$6,121,154	2%	$1,181,206	19,293	13.0%	$2,278,947	$626,884	$32.49
12	2024	$470,858	$5,650,296	2%	$1,204,830	21,141	14.3%	$2,547,106	$871,419	$41.22
13	2025	$470,858	$5,179,438	2%	$1,228,926	22,988	15.5%	$2,825,080	$1,125,296	$48.95
14	2026	$470,858	$4,708,580	2%	$1,253,505	24,836	16.8%	$3,113,154	$1,388,792	$55.92
15	2027	$470,858	$4,237,722	2%	$1,278,575	26,683	18.0%	$3,411,621	$1,662,189	$62.29
16	2028	$470,858	$3,766,864	2%	$1,304,146	26,683	18.0%	$3,479,854	$1,704,849	$63.89
17	2029	$470,858	$3,296,006	2%	$1,330,229	26,683	18.0%	$3,549,451	$1,748,364	$65.52
18	2030	$470,858	$2,825,148	2%	$1,356,834	26,683	18.0%	$3,620,440	$1,792,748	$67.19
19	2031	$470,858	$2,354,290	2%	$1,383,971	26,683	18.0%	$3,692,849	$1,838,020	$68.88
20	2032	$470,858	$1,883,432	2%	$1,411,650	26,683	18.0%	$3,766,706	$1,884,198	$70.61
21	2033	$470,858	$1,412,574	2%	$1,439,883	26,683	18.0%	$3,842,040	$1,931,299	$72.38
22	2034	$470,858	$941,716	2%	$1,468,681	26,683	18.0%	$3,918,881	$1,979,342	$74.18
23	2035	$470,858	$470,858	2%	$1,498,054	26,683	18.0%	$3,997,258	$2,028,346	$76.02
24	2036	$470,858	$0	2%	$1,528,015	26,683	18.0%	$4,077,203	$2,078,330	$77.89

Table E-6: Composting Facility Revenue and Cost Estimate

# Years	End of Year	Annual Depreciation on (Capital Assets)	Capital Asset Value	Inflation (%)	O&M Costs	Tons Diverted	Tons Diverted as % of Total	Gross Revenue	Net Revenue	Net Revenue per Ton
0	2012	$ -	$3,000,000	0%	$350,000	23,385	15.8%	$ -	-	-
1	2013	$ -	$3,060,000	2%	$357,000	23,385	15.8%	$ -	-	-
2	2014	$ -	$3,121,200	2%	$364,140	23,385	15.8%	$ -	-	-
3	2015	$ -	$3,183,624	2%	$371,423	23,385	15.8%	$ -	-	-
4	2016	$ -	$3,247,296	2%	$378,851	23,385	15.8%	$ -	-	-
5	2017	$162,365	$3,084,932	2%	$386,428	23,385	15.8%	$ -	$ (548,793)	$ (23.47)
6	2018	$162,365	$2,922,567	2%	$394,157	24,095	16.3%	$ -	$ (556,522)	$ (23.10)
7	2019	$162,365	$2,760,202	2%	$402,040	24,804	16.7%	$ -	$ (564,405)	$ (22.75)
8	2020	$162,365	$2,597,837	2%	$410,081	25,514	17.2%	$ -	$ (572,446)	$ (22.44)
9	2021	$162,365	$2,435,472	2%	$418,282	26,224	17.7%	$ -	$ (580,647)	$ (22.14)
10	2022	$162,365	$2,273,108	2%	$426,648	26,934	18.2%	$ -	$ (589,013)	$ (21.87)
11	2023	$162,365	$2,110,743	2%	$435,181	27,643	18.7%	$ -	$ (597,546)	$ (21.62)
12	2024	$162,365	$1,948,378	2%	$443,885	28,353	19.1%	$ -	$ (606,249)	$ (21.38)
13	2025	$162,365	$1,786,013	2%	$452,762	29,063	19.6%	$ -	$ (615,127)	$ (21.17)
14	2026	$162,365	$1,623,648	2%	$461,818	29,772	20.1%	$ -	$ (624,182)	$ (20.97)
15	2027	$162,365	$1,461,283	2%	$471,054	30,482	20.6%	$ -	$ (633,419)	$ (20.78)
16	2028	$162,365	$1,298,919	2%	$480,475	30,815	20.8%	$ -	$ (642,840)	$ (20.86)
17	2029	$162,365	$1,136,554	2%	$490,084	31,148	21.0%	$ -	$ (652,449)	$ (20.95)
18	2030	$162,365	$974,189	2%	$499,886	31,481	21.2%	$ -	$ (662,251)	$ (21.04)
19	2031	$162,365	$811,824	2%	$509,884	31,814	21.5%	$ -	$ (672,249)	$ (21.13)
20	2032	$162,365	$649,459	2%	$520,082	32,147	21.7%	$ -	$ (682,446)	$ (21.23)
21	2033	$162,365	$487,094	2%	$530,483	32,480	21.9%	$ -	$ (692,848)	$ (21.33)
22	2034	$162,365	$324,730	2%	$541,093	32,813	22.1%	$ -	$ (703,458)	$ (21.44)
23	2035	$162,365	$162,365	2%	$551,915	33,146	22.4%	$ -	$ (714,280)	$ (21.55)
24	2036	$162,365	$ (0)	2%	$562,953	33,812	22.8%	$ -	$ (725,318)	$ (21.45)

Table E-7: Landfill Gas to Energy Revenue and Cost Estimate

# Years	End of Year	Annual Depreciation on (Capital Assets)	Capital Asset Value	Inflation (%)	O&M Costs	Tons Diverted	Tons Diverted as % of Total	Gross Revenue	Net Revenue	Net Revenue per Ton
0	2012	$ -	$2,300,000	0%	$133,000	NA	NA	$1,730,000	-	NA
1	2013	$ -	$2,346,000	2%	$135,660	NA	NA	$1,764,600	-	NA
2	2014	$ -	$2,392,920	2%	$138,373	NA	NA	$1,799,892	-	NA
3	2015	$ -	$2,440,778	2%	$141,141	NA	NA	$1,835,890	-	NA
4	2016	$ -	$2,489,594	2%	$143,963	NA	NA	$1,872,608	-	NA
5	2017	$124,480	$2,365,114	2%	$146,843	NA	NA	$1,910,060	$1,638,737	NA
6	2018	$124,480	$2,240,635	2%	$149,780	NA	NA	$1,948,261	$1,674,002	NA
7	2019	$124,480	$2,116,155	2%	$152,775	NA	NA	$1,987,226	$1,709,971	NA
8	2020	$124,480	$1,991,675	2%	$155,831	NA	NA	$2,026,971	$1,746,660	NA
9	2021	$124,480	$1,867,195	2%	$158,947	NA	NA	$2,067,510	$1,784,083	NA
10	2022	$124,480	$1,742,716	2%	$162,126	NA	NA	$2,108,860	$1,822,254	NA
11	2023	$124,480	$1,618,236	2%	$165,369	NA	NA	$2,151,038	$1,861,189	NA
12	2024	$124,480	$1,493,756	2%	$168,676	NA	NA	$2,194,058	$1,900,902	NA
13	2025	$124,480	$1,369,277	2%	$172,050	NA	NA	$2,237,939	$1,941,410	NA
14	2026	$124,480	$1,244,797	2%	$175,491	NA	NA	$2,282,698	$1,982,728	NA
15	2027	$124,480	$1,120,317	2%	$179,000	NA	NA	$2,328,352	$2,024,872	NA
16	2028	$124,480	$995,838	2%	$182,580	NA	NA	$2,374,919	$2,067,859	NA
17	2029	$124,480	$871,358	2%	$186,232	NA	NA	$2,422,418	$2,111,706	NA
18	2030	$124,480	$746,878	2%	$189,957	NA	NA	$2,470,866	$2,156,430	NA
19	2031	$124,480	$622,398	2%	$193,756	NA	NA	$2,520,283	$2,202,048	NA
20	2032	$124,480	$497,919	2%	$197,631	NA	NA	$2,570,689	$2,248,578	NA
21	2033	$124,480	$373,439	2%	$201,584	NA	NA	$2,622,103	$2,296,039	NA
22	2034	$124,480	$248,959	2%	$205,615	NA	NA	$2,674,545	$2,344,450	NA
23	2035	$124,480	$124,480	2%	$209,728	NA	NA	$2,728,036	$2,393,828	NA
24	2036	$124,480	$ (0)	2%	$213,922	NA	NA	$2,782,596	$2,444,195	NA

Table E-8: Waste to Energy Revenue and Cost Estimate

# Years	End of Year	Annual Depreciation on (Capital Assets)	Capital Asset Value	Inflation (%)	O&M Costs	Tons Diverted	Tons Diverted as % of Total	Gross Revenue	Net Revenue	Net Revenue per Ton Diverted
0	2012	$ -	$150,000,000	0%	$10,000,000	80,000	54.0%	$7,000,000	-	-
1	2013	$ -	$153,000,000	2%	$10,200,000	80,000	54.0%	$7,140,000	-	-
2	2014	$ -	$156,060,000	2%	$10,404,000	80,000	54.0%	$7,282,800	-	-
3	2015	$ -	$159,181,200	2%	$10,612,080	80,000	54.0%	$7,428,456	-	-
4	2016	$ -	$162,364,824	2%	$10,824,322	80,000	54.0%	$7,577,025	-	-
5	2017	$8,118,241	$154,246,583	2%	$11,040,808	80,000	54.0%	$7,728,566	$ (11,430,484)	-142.88
6	2018	$8,118,241	$146,128,342	2%	$11,261,624	80,000	54.0%	$7,883,137	$ (11,496,728)	-143.71
7	2019	$8,118,241	$138,010,100	2%	$11,486,857	80,000	54.0%	$8,040,800	$ (11,564,298)	-144.55
8	2020	$8,118,241	$129,891,859	2%	$11,716,594	80,000	54.0%	$8,201,616	$ (11,633,219)	-145.42
9	2021	$8,118,241	$121,773,618	2%	$11,950,926	80,000	54.0%	$8,365,648	$ (11,703,519)	-146.29
10	2022	$8,118,241	$113,655,377	2%	$12,189,944	80,000	54.0%	$8,532,961	$ (11,775,224)	-147.19
11	2023	$8,118,241	$105,537,136	2%	$12,433,743	80,000	54.0%	$8,703,620	$ (11,848,364)	-148.10
12	2024	$8,118,241	$97,418,894	2%	$12,682,418	80,000	54.0%	$8,877,693	$ (11,922,967)	-149.04
13	2025	$8,118,241	$89,300,653	2%	$12,936,066	80,000	54.0%	$9,055,246	$ (11,999,061)	-149.99
14	2026	$8,118,241	$81,182,412	2%	$13,194,788	80,000	54.0%	$9,236,351	$ (12,076,677)	-150.96
15	2027	$8,118,241	$73,064,171	2%	$13,458,683	80,000	54.0%	$9,421,078	$ (12,155,846)	-151.95
16	2028	$8,118,241	$64,945,930	2%	$13,727,857	80,000	54.0%	$9,609,500	$ (12,236,598)	-152.96
17	2029	$8,118,241	$56,827,688	2%	$14,002,414	80,000	54.0%	$9,801,690	$ (12,318,965)	-153.99
18	2030	$8,118,241	$48,709,447	2%	$14,282,462	80,000	54.0%	$9,997,724	$ (12,402,980)	-155.04
19	2031	$8,118,241	$40,591,206	2%	$14,568,112	80,000	54.0%	$10,197,678	$ (12,488,675)	-156.11
20	2032	$8,118,241	$32,472,965	2%	$14,859,474	80,000	54.0%	$10,401,632	$ (12,576,083)	-157.20
21	2033	$8,118,241	$24,354,724	2%	$15,156,663	80,000	54.0%	$10,609,664	$ (12,665,240)	-158.32
22	2034	$8,118,241	$16,236,482	2%	$15,459,797	80,000	54.0%	$10,821,858	$ (12,756,180)	-159.45
23	2035	$8,118,241	$8,118,241	2%	$15,768,993	80,000	54.0%	$11,038,295	$ (12,848,939)	-160.61
24	2036	$8,118,241	$ -	2%	$16,084,372	80,000	54.0%	$11,259,061	$ (12,943,553)	-161.79

Table E-9: Sensitivity Analysis of Recovery Rates on Material Recovery Facility Revenue Estimates (2037)

Material Group	Material	Estimate of Recovered Tons of Recyclables						Unit Price[b]	Estimated Revenue Range from Recovered Recyclables	
		Residential		Commercial		Total				
		Low	High	Low	High	Low	High		Low	High
Paper	Newsprint	946.3	1,529.5	0.0	1,445.6	946.3	2,975.2	$90/ton	$85,165.74	$267,764.52
	Magazines	481.2	777.7	0.0	763.7	481.2	1,541.5	$90/ton	$43,304.61	$138,731.15
	High Grade Office Paper	128.3	207.4	0.0	627.4	128.3	834.7	$90/ton	$11,547.90	$75,127.33
	OCC and Kraft Bags	801.9	1,296.2	0.0	3,082.2	801.9	4,378.4	$130/ton	$104,251.85	$569,195.58
	Mixed Recyclable Paper	1,267.1	2,048.0	0.0	1,445.6	1,267.1	3,493.6	$90/ton	$114,035.48	$314,427.66
	Compostable Paper	1,251.0	2,022.1	0.0	2,236.7	1,251.0	4,258.7	$0/ton	$0.00	$0.00[c]
	Total	*4,875.8*	*7,880.9*	*0.0*	*9,601.3*	*4,875.8*	*17,482.2*		*$358,305.58*	*$1,365,246.25*
Plastics	#1 PET Beverage Containers	96.2	155.5	0.0	81.8	96.2	237.4	$465/ton	$44,748.10	$110,378.40
	#1 PET Deposit Beverage Containers	64.2	103.7	0.0	136.4	64.2	240.1	$465/ton	$29,832.07	$111,636.13
	#2 HDPE Containers	240.6	388.9	0.0	354.6	240.6	743.5	$500/ton	$120,290.59	$371,726.12
	#6 Polystyrene	192.5	311.1	0.0	627.4	192.5	938.4	$0/ton	$0.00	$0.00[c]
	Other Plastic Containers	64.2	103.7	0.0	109.1	64.2	212.8	$0/ton	$0.00	$0.00[c]
	Other Plastic Products	513.2	829.6	0.0	1,063.8	513.2	1,893.3	$0/ton	$0.00	$0.00[c]
	Total	*1,170.8*	*1,892.4*	*0.0*	*2,373.0*	*1,170.8*	*4,265.5*		*$194,870.76*	*$593,740.64*
Metals	Aluminum Deposit Beverage Containers	64.2	103.7	0.0	109.1	64.2	212.8	$1,360/ton	$87,250.78	$289,409.80
	Ferrous Food and Beverage Containers	272.7	440.7	0.0	381.9	272.7	822.6	$140/ton	$38,172.21	$115,160.72

Material Group	Material	Estimate of Recovered Tons of Recyclables							Estimated Revenue Range from Recovered Recyclables	
		Residential		Commercial		Total				
		Low	High	Low	High	Low	High	Unit Price[b]	Low	High
	Others Ferrous Metals	320.8	518.5	0.0	436.4	320.8	954.9	$140/ton	$44,908.49	$133,686.16
	Other Non-ferrous Scrap	224.5	362.9	0.0	300.0	224.5	663.0	$/ton	$0.00	$0.00[c]
	Total	*882.1*	*1,425.8*	*0.0*	*1,227.4*	*882.1*	*2,653.3*		*$170,331.48*	*$538,256.68*
Glass	Glass Non-deposit Containers	417.0	674.0	0.0	545.5	417.0	1,219.6	$7/ton	$2,919.05	$8,536.85
	Glass Deposit Containers	240.6	388.9	0.0	436.4	240.6	825.3	$7/ton	$1,684.07	$5,776.97
	Other Glass/ Mixed Cullet	96.2	155.5	0.0	81.8	96.2	237.4	$0/ton	$0.00	$0.00[c]
	Total	*753.8*	*1,218.4*	*0.0*	*1,063.8*	*753.8*	*2,282.2*		*$4,603.12*	*$14,313.82*
Total Recyclables		**7,682**[a]	**12,418**[a]	**0**[a]	**14,265**[a]	**7,682**	**26,683**		**$728,110.94**	**$2,511,557.39**[d]

Estimated Revenues Per Ton Diverted ***$94.78***[e] ***$94.13***

Notes:

a Tons of recyclables recovered in 2037. Refer to RRP FS Table 13 for Residential Tons and Table 16 for Commercial Tons.

b For unit prices, refer to RRP FS Table 2 Commodity Price. Prices for Paper, Plastic, Glass and Aluminum were based on GID which are reflective of Kauai. Prices for all ferrous Metals or bi-metals were available from RRR Recycling. Average price was assumed.

c No revenue estimated to be received for recovered material.

d Revenue estimates shown do not include annual inflation.

e Approximately $95 per ton is used for planning purposes.

Appendix F
Response to Community Comments

ID	Comment
RRP Concept	
1	<u>Implementation</u> • How will facilities be implemented (in what order)? (Hanamaulu Mtg.) • Where will diversion facilities be located in relation to the landfill? The RRP should be at the landfill entrance. (Hanamaulu Mtg.) • What is the proposed start date of the RRP? There should be greater emphasis on the start date and the urgency of starting. (Kekaha Mtg.) • It seems it would be simpler and less expensive to locate those elements of the Resource Recovery Park which are appropriate, on the actual landfill site as it is State land. This would simplify integration of operations, reduce capital and operating costs and give the County more control over the operations of the various diversion options. We do not like the “alternative RRP” site idea. (written comment) • Location. Concur with a RRP lying in the same vicinity as the landfill. Both should be situated where the majority of the waste stream is originating from, i.e. on the east side of Kauai where the population and business density is greatest. The savings in trash hauling cost over the lifetime of the landfill will be immense. (written comment)

Response:

- The order in which facilities will be implemented is a function of technical requirements, future needs, and other considerations, including economics. It is anticipated that drop-off facilities and the permanent depot for household hazardous waste and electronic waste would be among the first facilities considered for implementation.
- The RRP would be located in a manner to encourage maximum use of the diversion programs and facilities while discouraging disposal.
- The proposed start date for the RRP is expected to coincide with the opening of the new landfill site, and is dependent on many factors.
- The County is considering the implications of locating the RRP at the new landfill site or the nearby alternate site.
- It is anticipated that the County may continue to operate many or all elements of its current network of decentralized drop off facilities in the near future, to support diversion activities across the County. The proposed implementation of curbside collection of recyclables and greenwaste from households may expand the convenience of the existing programs in outlying areas. The existing drop off centers could be repurposed to more closely align with the services provided at the RRP.

ID	Comment
2	<u>Alternatives to the RRP</u> • Have alternatives been identified and costed to RRP concept? (written comment) • Have you identified any disposal methods that contribute less pollutants than the RRP method? (written comment) • RCRA – are we consuming more non-renewables like oil to divert our solid waste? Is it cost effective? (written comment) • Are there similar-sized RRPs to Kauai and have they achieved their proposed diversion goals? (Kekaha Mtg.) • Need the MRF Yesterday! - Tying the much needed MRF into the Landfill and the RPP would

ID	Comment
	result in unacceptable delays in getting curbside recycling up and going. (written comment)

Response:

- The County identified a range of alternatives to be considered as part of the overall RRP. An estimate of the capital cost and annual operations and maintenance cost was developed for each alternative.
- The RRP is intended to include an integrated set of programs and facilities to support maximization of waste reuse, recycling and recovery and minimize environmental effects from waste disposal. Through effective design and use of BMPs, the RRP is not expected to contribute significantly greater amounts of pollutants to the environment compared to other alternatives.
- The RRP FS recommends a set of programs and facilities to assist the County in achieving its waste diversion target. It is not anticipated that the RRP would result in an overall increase in consumption of non-renewables but in fact would assist in increasing the net recovery of valuable resources.
- The RRP is simply a single central location for the County's waste reuse, recycling and recovery activities. These types of facilities exist in a variety of forms and configurations throughout North America. The programs and facilities located at the RRP will require support through County policy, enforcement, and public education in order for the County's diversion goal to be achieved.
- The County is in the process of considering plans for the development of a material recovery facility in the short term to support the implementation of curbside collection of recyclables.

3	Funding • There should be a greater consideration of the economics behind the RRP. (Kekaha Mtg.) • If the County has budgeting restraints, will the RRP be cut before the landfill? (Hanamaulu Mtg.) • What is the projected operational cost of the RRP and what will be the funding mechanism? (written comment) • Who/how will the RRP be funded? (written comment)

Response:

- Capital and operating costs, plus potential revenues, associated with each potential program or facility identified as part of the RRP have been identified and considered. Economic conditions and the financial capacity of the County will also influence implementation of the RRP.
- The County has existing waste diversion programs in place which will continue to operate in the event that funding of the RRP development is delayed.
- Capital and operating cost estimates have been developed for each of the programs and facilities proposed as part of the RRP. Some funding will be available through revenues from the sale of recovered materials. Other operational costs will likely be funded as part of the County's annual operating budget.

4	Cost-to-Benefit Considerations • How many jobs will the RRP create? (Kekaha Mtg.)

ID	Comment
	• Has curbside commingled recycling been analyzed for percent and cost and the effect of RCRA? (written comment) • What is the cost of all the recycling per ton now vs. the new RRP? (written comment) • What are the cost to benefit for all diverted waste streams? (written comment) • What is the population threshold to make the RRP viable? (Hanamaulu Mtg.)

Response:

- The RRP FS includes an estimate of staff requirements for the various programs and facilities. It is anticipated that a number of programs and facilities will be operated by a contractor and that there may be operational synergies between various facilities. The actual number of jobs created will be determined once these operational details are confirmed.
- The County is currently proposing to implement a program for the curbside collection of commingled household recyclables. The RRP may include a material recovery facility to receive and process the recyclables for market.
- The cost to benefit for the various waste streams has been identified in the RRP FS.
- The various components of the RRP are sized to accommodate the projected quantity of the various waste materials targeted for diversion, and therefore there is no specific population threshold to make the RRP concept viable.

RRP Operation and Components

ID	Comment
5	<u>Landfill Gas-to-Energy</u> • Can enough organics be diverted to entirely discount landfill gas-to-energy? (Hanamaulu Mtg.) • Landfill gas to energy – too much diversion to produce enough gas to make it viable? (written comment)

Response:

- It is possible that sufficient quantities of organics may be diverted from landfill such that landfill gas to energy could be less viable in the future. The volume of landfill gas generated would be monitored to confirm if development of a landfill gas to energy facility should proceed. Additionally, it is recommended to develop the LFGtE facility modularly, which would help the County match the availability of LFG.

ID	Comment
6	<u>Waste-to-Energy (Incineration)</u> • If a burn plant is implemented where will the ash go? (written comment) • What would the capital and O&M costs for plasma arc be compared to a RRP with 4F and potential burn plant? (written comment)

Response:

- The ash remaining from the combustion of waste would likely require disposal in a separate landfill cell from municipal solid waste.
- There is very limited data available associated with the costs of a plasma arc facility for municipal solid waste. There are no commercial scale facilities currently operating in North America. Appendix G provides some case studies of existing plasma arc facilities, for reference. Typical costs for a more traditional waste to energy facility are included in the RRP

ID	Comment
	FS.
7	Household Hazardous Wastes • Compact fluorescent light disposal should be included in the RRP. (Hanamaulu Mtg.)

Response:

- Compact fluorescent light bulbs would be collected at the household hazardous waste (HHW) depot.

ID	Comment
8	Staffing • Who will manage/operate the RRP? (Hanamaulu Mtg.) • The *Kea'au Recycling and Reuse Center* – employs people with developmental disabilities will Kaua'i County consider this option to employ the incredible work ethic amongst this population? • There was a question at the meeting on the number of jobs the RRP would create for Kauai. While the creation of jobs on Kauai is welcomed, we must be careful to avoid increasing the burden on the county taxpayers. The Ma'alo site is adjacent to Wailua, and the Kauai Community Correctional Center (KCCC). Inmates at KCCC could be put to use at the RRP to segregate the reusable/recyclable content from the thrash. An inmate work release program of this sort presents a useful way for inmates to repay their debt to society, and may prove to have rehabilitative benefits with inmates coming to feel good about this sort of work, and the positive stewardship it represents for the island of Kauai. (written comment)

Response:

- The County will manage the RRP and it is anticipated that the majority of the RRP programs and facilities will be operated by a contractor(s).
- The County will consider how best to operate and staff the various RRP facilities at the time of implementation.

ID	Comment
9	Transport of Materials to the RRP • How will RRP materials be brought from residents, Hotel Industry, Costco, e-waste, Public and Private Schools, restaurants, gated communities, and et cetera? (written comment) • "Resource conservation" part of RCRA is being ignored. Increasing recycling collection throughout the island will increase hauling and use more fossil fuels, etc. (Hanamaulu Mtg.)

Response:

- The RRP would receive materials from residents and small, direct haul commercial generators at the drop off area. Large loads of recyclable materials and greenwaste would be taken directly to the appropriate processing facility.
- Increased recycling promotes conservation through the capture of valuable resources for reuse and recycling.

ID	Comment
10	Electrical Needs • How will the RRP be powered? (Kekaha Mtg.)

Response:

ID	Comment

- Specific detailed design issues have not been considered at this point in the process.

11	Material Quantities • Are 2007 [Beck waste composition study] quantities valid/accurate? (Hanamaulu Mtg.) • Not all paper is recyclable – BFI analysis came up with less than 40% of paper could be recycled and rest was contaminated. (written comment) • Have quantities of "truly" recyclable materials been made? (written comment) • Have you analyzed the quantity of paper fibers in the current waste stream? (written comment)

Response:

- The waste composition data contained in the 2009 Beck ISWMP is the most current data available. Potential limitations of the data have been identified in the feasibility study. The feasibility study estimates the type and quantity of materials that can be diverted through each of the different programs and facilities proposed at the RRP.
- The possibility that not all paper can be recycled has been considered in the feasibility study, and an estimate of the quantity of paper fibers in the current waste stream is included.

Potential Reuse and Resale of Materials

12	Inter-County Cooperation • Can the Counties work together to achieve greater recycling and overcome economies of scale? (Kekaha Mtg.) • Are the Counties in Hawaii looking to develop RRPs to address their landfill situations? There may be opportunities of scale to develop multiple RRPs statewide. (written comment) • I would just like to add that there is not likely to be the sustained waste stream on Kauai to cost effectively supply a Waste to Energy plant on Kauai. BUT, I would like to recommend that Kauai County consider becoming one of the suppliers with appropriate portions of its waste stream to the Waste to Energy plant that WILL BE built on Maui. Kauai may be able to SELL unrecycled waste to Maui for that purpose. (written comment)

Response:

- The feasibility study included a review of recycling programs in the other Counties to identify whether opportunities for co-operation and economies of scale for materials processing may be available. There are, however, cost, logistical, and other hurdles.
- The level of development of recycling programs and initiatives varies across the Counties. The RRP is simply a single central location for the County's waste reuse, recycling and recovery activities. Opportunities of scale may exist across the Counties for the processing and marketing of specific materials, and can be pursued, if appropriate.
- The RRP feasibility study recognizes that waste to energy may be cost effective on Kauai in the future as technology evolves. It is recommended that space be reserved at the RRP to accommodate this situation in the future. This could also include providing waste to a new waste to energy facility in Maui, if favorable conditions develop.

13	Markets for Collected Materials

ID	Comment
	• How do we recycle here? What kinds of opportunities are there to make products from recycled materials on Kauai? Could Kauai import recyclables if there were plastic reprocessing for instance? (Kekaha Mtg.) • Thrift shops placing tons of discarded donations into dumpsters – I have witnessed this extensive contribution to the landfill. This practice is wasteful…Ever notice the price of a package of buttons at Wal-Mart of Lihuʻe Housemart & *ACE* Hardware and Crafts? As well, there are plenty mechanic businesses on BEAUTIFUL Kauaʻi – bags of rags – are sold at various stores for BIG money. (written comment) • Where are electronic waste and household hazardous waste going now? (Hanamaulu Mtg.) • How much recyclable product is expected and have "willing" consumers been identified? (written comment) • What is the value of recovered materials? Can the RRP help to pay for itself? (Hanamaulu Mtg.) • Consider making efforts to reduce the cost of transport of recyclables to market through backhauling. (Kekaha Mtg.) • Residential reuse. Ideally, the RRP would offer wide reuse of the resources collected to island residents. Appliance parts, automobile parts, knick-knacks, what have you, if people can leave the park with stuff they can use at home, that represents a major win-win opportunity. Couple of particular items of interest is soil and automobile tires. If the RRP can provide soil testing and certify soil to be free of contaminants, a lot of homeowners would likely take advantage of it in landscaping work at home. Furthermore, if the tire processing portion of the park went beyond just bundling and palletizing tires and removed one side sidewall from the tires it collected, those tires would make excellent receptacles for holding dirt and building retaining walls. (written comment)

Response:

- At present there are limited recycling facilities or operations on Kauai that process materials for resale. With increased recycling and quantities of materials captured, businesses may consider the development of reprocessing facilities on Kauai in the future, which the RRP could support.
- Education and awareness will continue to be a key component of the County's overall waste management program to discourage wasteful practices.
- It is proposed that the RRP include a permanent depot for the collection of electronic waste and household hazardous waste. Electronic waste is currently collected at scheduled events and eventually shipped to the mainland for reuse, reprocessing, and recovery of materials. Household hazardous waste is collected during annual events and most of the material is shipped to Oahu for bulking purposes before transport to a mainland hazardous waste landfill.
- The County has set a target of 70% waste diversion from the landfill. The feasibility study identifies the projected diversion that may be achieved through each of the RRP programs and facilities. Most "consumers" and recyclers of recovered materials are currently in Asia and the mainland U.S. Potential opportunities for reuse and recycling in Hawaii will continuously be evaluated.
- The feasibility study identifies an estimated range of revenue from the sale of recovered

ID	Comment
	recyclables. This revenue can assist in offsetting costs associated with the material recovery facility. Other programs including the collection of household hazardous waste have no revenue potential but are of significant benefit to the environment. • The investigation of backhauling of recyclables was recommended in the Integrated Solid Waste Management Plan. The County intends to consider this further. • The Reuse and Hard to Recycle Materials center is intended to be able to support value added waste diversion opportunities and waste reuse, such as those suggested, if a market is identified for specific materials.
Landfill Diversion	
14	<u>Decentralized Approach</u> • Ways in which different regions/communities can support diversion should be looked into. Incorporate the ahupuaʻa system. (Kekaha Mtg.) • Recommend expanding the convenience of RRP collection to outlying areas. (Hanamaulu Mtg.) • Needs vs. wants - The issue of developing a Resource Recovery <u>Park</u> vs. an integrated Resource Recovery <u>System</u> has not been addressed in the Feasibility Analysis. Siting all diversion operations at a single location may not be the most efficient or convenient solution to managing our discards. It may make more sense, logically and cost effective to have the facilities more distributed. (written comment) • The draft study suggested the possibility of an Integrated Public Drop Off center at the RRP. The expense of this portion might be better put to use in more satellite collection points around the island, as the drop off point at the RRP would tend to be most utilized by those in close proximity to the drop off. The easier it is for island residents to participate in the recycling effort, the more likely it is that they will. One thought for satellite drop off locations would be to make them drive-through facilities. For instance, a drive-through development at the base of Moi Road in Hanapepe where all Hanapepe Heights vehicle traffic must pass through may entice most of those residents into doing their part. For some communities, drive-through collection points would be more feasible than the curbside recycling program discussed in the draft study. (written comment) • Need Regional Facilities / Drop off- sites - The proposed RRP focuses on a single Central Composting Facility, Charm, etc., rather than addressing the need for regional facilities. Regional facilities could be located closer to the point of generation and collection, for instance in the case of composting it should be near regional agricultural operations which would be a major market for the finished product. (written comment) o Is it intended that the drop-off facilities be used by residents in the outlying communities? Do you really think that North Shore & West Side residents will use the facility, let alone East Side and South Side residents? o Why locate the community drop-off elements of the RRP all the way up at Maalo? If the intent is just to service the Līhuʻe area, isn't that a lot of money when the core of those facilities already exist at the Lihue Transfer Station which is much more convenient to the Community? o Location, Location, Location - It seems more efficient, safer, and more logical to

ID	Comment
	locate elements of the RRP such as the MRF, the Center for Hard to Recycle Material, and residential and small commercial waste and greenwaste drop sites in a more convenient location with better access to the harbors it is ultimately all being shipped off-island. o Locating all of the Public Drop-off elements and the MRF other places would significantly reduce the traffic impacts on Maalo Rd and the Kūhiʻō Hwy. In addition, it would minimize the potentially unsafe mix of residential and commercial traffic (small cars and big trucks).

Response:

- It is anticipated that the County will continue to operate its current network of decentralized drop off facilities to support diversion activities across the County.
- The proposed implementation of curbside collection of recyclables and greenwaste from households will expand the convenience of the existing programs in outlying areas. The existing drop off centers could be repurposed as a result to more closely align with the services provided at the RRP, and the County will continually evaluate the best ways to increase collection of materials.
- Traffic effects associated with the RRP will be assessed as part of the overall EIS for the new landfill site.

15	Food Waste • Are there other beneficial uses of food waste? Establish a food recovery network, including houses, restaurants, and hotels. (Kekaha Mtg.) • There is tons of discarded food waste at schools – what happened to the pig farmers that would be up the slop (sic)? Ten (10) billion people go to bed hungry every day. There isn't any viable composting at any public schools – that contributes immensely to the landfill problem. (written comment) • Get the Organics Out! - An evaluation should be made of the benefits of establishing a policy of banning (maximizing the diversion of) all wet organic material (food waste, sludges, grease trap waste, etc) thereby minimizing environmental and nuisance impacts such as odors, methane generation and leachate toxicity. (written comment)

Response:

- In order to maximize waste diversion, municipalities are implementing programs for collection of food waste for composting, as feasible.
- The programs and facilities located at the RRP will require support through County policy, enforcement and public education in order for the County's diversion goal to be achieved. This could include policy related to banning disposal of some forms of organic materials.

16	Green Waste • Green waste at schools on our island…?? What happened to the *USDA 4-H* program on Kauaʻi? (written comment)

Response:

- Greenwaste managed by commercial haulers is banned from landfill disposal on Kauai and it is directed to the County's transfer stations or hauled directly to one of the local compost

ID	Comment
	facilities.
16	<u>Center for Hard to Recycle Materials</u> • The development of a CHARM should address the need for a facility to accept hazardous waste from small commercial generators (Conditionally Exempt Small Quantity Generator - CESQG waste). These wastes need to be managed to assure they are not getting into the landfill – not sure the current "honor system" is good enough. (written comment) • Why are there no bulky items (furniture, mattresses, large toys, yard furniture, etc included in the durables) managed by the CHARM? (written comment)

Response:

- Small quantities of hazardous wastes may be received from small commercial generators at the permanent household hazardous waste (HHW) depot recommended as part of the RRP.
- Bulky items such as furniture that can be reused or refurbished would be managed through the Reuse Center. The CHARM would manage materials such as mattresses if a market for the material has been identified.

ID	Comment
17	<u>County Policies</u> • Need to emphasize monetary incentives to encourage people to recycle. (Kekaha Mtg.) • Enforcement: that's where planning will come in to keep this kind of waste from happening. Enforcement is a necessary component that would be win/win – the creation of jobs and to raise public awareness. (written comment) • The Feasibility Study needs to touch on those County policies and programs "external" to the RRP that are necessary to make it work. Programs such as: Pay As You Throw; banning all wet organics; Commercial and Construction recycling mandates; and Bans on the sale of specific materials such as styrofoam containers and disposable plastic water bottles should be an essential part of the approval of any disposal site. (written comment) o How would the implementation of Extended Producer Responsibility legislation (requiring importers and manufacturers to develop programs to take back their products) impact the RRP proposal?

Response:

- The County may consider future incentives and enforcement opportunities to help support waste diversion programs. Such policies or regulations, while perhaps worthwhile, are beyond the scope of this project. The RRP may be able to support implementation of such potential future policies.
- The programs and facilities located at the RRP will require support through County policy, enforcement and public education in order for the County's diversion goal to be achieved. Specific policies will be developed and implemented by the County as required. The impact of Extended Producer Responsibility legislation would depend on the type and range of products covered by the legislation.

ID	Comment
18	<u>General</u> • The 70% diversion goal should be higher. (Hanamaulu Mtg.) • How will recycling education keep up with new technologies, etc.? (Hanamaulu Mtg.) • Imua. The RRP must be part and parcel to the planning of the new landfill on Kauai. A tiny

<table>
<tr><th>ID</th><th>Comment</th></tr>
<tr><td></td><td>island like Kauai has very limited space. We must ensure that the amount we utilize and keep in reserve for waste “interment” is kept to a minimum. To that end, resource recovery/recycling is a must. Keep pressing forward on this initiative. (written comment)</td></tr>
<tr><td colspan="2">Response:
The County will continue to assess its waste diversion rate relative to the overall goal and make adjustments in the future as appropriate.
The County regularly reviews and updates its education materials to support increased waste diversion. This practice will continue as new programs and facilities are introduced.
The site layout and design for the RRP will be optimized prior to development in order to make the most efficient use of the land resources available.</td></tr>
<tr><td colspan="2">Environmental Impacts</td></tr>
<tr><td>19</td><td><u>Surface and Groundwater</u>
Concerned regarding surface and groundwater impacts. (Hanamaulu Mtg.)
The runoff considerations associated with paving the site need to be addressed. (Hanamaulu Mtg.)
Reef tourism is an $800M industry annually in the state. The site is terrible for watershed and reef protection. (Hanamaulu Mtg.)
The landfill and RRP will increase storm water runoff. Is the County planning to basically abandon the watershed to pollution? (Hanamaulu Mtg.)
If the landfill infiltrates the drinking water supply, how will the County address the potential shutdown of Wilcox Memorial Hospital, all the medical facilities in Lihue, the schools, government operations, businesses, and retail operations? (written comment)</td></tr>
<tr><td colspan="2">Response:
The design of the RRP site will include measures to mitigate potential effects to surface water and groundwater.</td></tr>
<tr><td colspan="2">Presentation Comments</td></tr>
<tr><td>27</td><td><u>General</u>
Shorten and make the presentation more concise. There should be more audience interaction. (Kekaha Mtg.)
You need to seriously consider the following (written comment):
How to make your presentations brief and relevant to your audience.
That it is not necessary to go into detail which your audience will not be able to retain.
Select “highlights” that will capture your audience’s interest and attention.
Consider ways in which small group discussions may be used to maximize opportunities for community members to participate in the process of interaction on the subject being discussed.
First of all, mahalo for the time and effort to keep the community informed and apprised of the realm of possibilities in establishing new ways in which we should be handling our opala</td></tr>
</table>

ID	Comment
	here on Kauai. (written comment) It is a monumental task and the enormous amount of work that has been put into this effort is readily apparent. I humbly offer these suggestions for your consideration: o While it is understandable that you wish to provide the wealth of information that is pertinent to the project, TOO MUCH information at one sitting may not be the best way to accomplish that task. There is simply an over-abundance of information that cannot be retained. o I think it would be more palatable to let your audience know where to get the information for them to review at their leisure if they want to get ALL of the detailed information. That way, the presentation can be presented with efficiency by HIGHLIGHTING particular aspects which may be of interest. o I would strongly suggest to concentrate on the factors that will be the "leading components" of the pitch. Imagine, if you will, being a car salesman! In making the sale, which highlights should be featured? Efficiency? Savings? Economic Viability? Whatever the case may be, by focusing on some of those key points, I think your audience may retain interest and enthusiasm in the subject matter. o It may not be possible to get things done by tonight, but if you could concentrate on a few of the audio-visual aspects to concretize the concept or the plan…….do so. o If you are going to retain "several parts" to the presentation, I think it would be far better to be as brief and concise with each part, and allow for a 5 to 10 minute follow-up session of questions and/or comments to that part so that there could be focused inter-change among those in attendance on what is being discussed. It is never "more effective" to go through the ENTIRE MEAL without enjoying each of the courses. We enjoy each of the separate parts of a 9 course dinner for what each is! o You should be asking yourselves these questions: What do I want to accomplish? What are the different ways in which I can make this information interesting and relevant to my audience? How can I get them to respond? In doing so, you may want to limit each segment with 3 to 5 components so as not to overwhelm your audience with every detail about every aspect each step of the way. If the audience gets so "into" what you are saying, you might have to head them off by letting them know that you appreciate their enthusiasm and interest, but the meeting has planned a lot more, so they will have to wait until "next time". If they want to stay on the subject, YOU (the speaker) can decide whether you should continue because you have been so successful…..or you can say……."It's time to move on!" I commend you for your commitment and dedication in the monumental work you are doing. It is in the "presentation of the material" which requires some fine-tuning.

ID	Comment

Response:

- Thank you for the comments. The presentation format and style will be reassessed for any future meetings. The County will continue to consider what material needs to be communicated to the public through future presentations and the how best to meet the needs and expectations of the community.

New Landfill Related Issues	
40	<u>General</u> • The County cannot please everyone; there will always be NIMBYs. County must sell it and promote sustainability. (Kekaha Mtg.) • The EIS should be for the entire project. (Hanamaululu Mtg.) • How was the site chosen? Will the siting be addressed in the EIS? (Hanamaululu Mtg.) • Landfill liners last thirty (30) years not two-hundred. (written comment) • It would be considerate for Kaua'i County to contact the numerous helicopter, aerial, airplane tour business' operators to receive *their* testimony of how this proposal: *NSWLF* will affect *their* cliental (sic). (written comment)

Response:

- Comments directly related to the New Landfill/RRP EIS will be addressed in the EIS.

Appendix G
Waste to Energy Background and Case Studies

APPENDIX G: OTHER WASTE-TO-ENERGY TECHNOLOGIES – BACKGROUND AND CASE STUDIES

Contents

G-1 PYROLYSIS

G-1.1 OVERVIEW

Pyrolysis is the thermal decomposition of carbon-based materials using an indirect source of heat to produce a synthetic gas (syngas). The process uses temperatures of 400 to 900 ^{o}C with no air or oxygen present. At high temperatures, the organic compounds volatilize and bonds thermally crack, breaking larger molecules into gases and liquids composed of smaller molecules, including hydrocarbon gases and hydrogen gas. Lower temperature pyrolytic reactions produce syngas that can be used in a variety of ways.

Pyrolysis can process a wide-range of carbon-based materials; however, if a homogenous feedstock is used, a higher quality byproduct is produced. The pyrolysis process produces carbon monoxide, hydrogen gas, methane, carbon dioxide, and water. MSW is not a homogenous waste stream and inorganic materials (metals, glass, rocks, concrete, etc.) that do not enter the thermal conversion reactions make the process less efficient; inorganic materials are cooled in the clean-up process and the heat energy is lost. Therefore, some pre-processing of MSW is typically required to remove non-degradable inorganic materials. Pre-processing may include sorting, separation, size reduction, and densification.

Pyrolysis typically results in a large unreacted portion of the feedstock remaining in the form of carbon char. Ash (inorganic materials) present in the feedstock also does not react and must be disposed as char/ash.

A minimum throughput of 30 to 40 tons/day is needed for pyrolysis. The higher the throughput level, the lower the cost per ton for pyrolysis treatment. The largest MSW pyrolysis plant in operation is the Toyohashi City facility in Japan, which processes 400 tons/day of MSW.

In North America, most pyrolysis plants are relatively small-scale and typically only process biomass (forestry lumber mill, or crop wastes). As of 2011, there were no commercial-scale permitted MSW pyrolysis facilities in the U.S. Currently, there are only a few operating MSW pyrolysis facilities worldwide, mostly in Europe and Japan; such facilities are discussed below.

G-1.2 PYROLYSIS FACILITIES

G-1.2.1 GEM Flash Pyrolysis Thermal Process Facility (Scarborough, U.K.)

This facility is a demonstration plant to convert a MSW derived solid recovered fuel (SRF) into syngas for combustion in a gas engine to generate electricity. Feedstock is shredded (<25 mm) by a processor before transfer to the GEM facility, and is then granulated (< 2mm) and dried (3% - 5% moisture) prior to the pyrolysis process. The GEM pyrolysis facility is sized to operate on a continuous basis to process 1.5 tons/hour (TPH) of SRF.

The GEM pyrolysis converter operates at a temperature of 810 ^{o}C. The outer chamber of the pyrolysis converter is heated by gas burners fuelled using either natural gas or the syngas produced by the pyrolysis process (Williams and Barton 2010).

Syngas is conveyed to two sequential gas coolers that remove water and hydrocarbons from the syngas. The cooled syngas is then pressurized and passed into a gas buffer tank before combustion in a reciprocating (diesel) gas engine for electrical generation. The engine is initially started with only natural gas, and then uses only syngas. The generator is designed to produce 1.8 MW of electricity from the 18,000 TPY input of SRF.

The GEM facility was originally constructed in late 2008. Within the first several months of startup, several problems occurred (Williams and Barton 2010).

- Major design flaws including wiring philosophy, pump sizes, motor sizes, pipe diameters, etc.
- Electrical load required by the plant was underestimated and forced the entire system to be redesigned.
- Heat loss from the gas system was higher than predicted.
- Overly complicated software control system extended commissioning and reduced plant reliability.
- Drier and exhaust systems were not appropriately designed and therefore required modifications.

Re-design of the system was estimated to take a year and the process is still considered unproven.

G-1.2.2 Mullpyrolyseanlage Pyrolysis Plant (Burgau, Germany)

This facility began operations in 1984, processes 38,580 TPY of MSW (residential, commercial, bulky waste, sewage sludge), and uses 3 acres of land adjacent to a closed landfill. All feedstock materials must be shredded to 12 inches or less prior to the pyrolysis process. The system includes refuse treatment, two rotary kilns, dust separation, a combustion chamber for pyrolysis gas incineration, a waste heat boiler, a steam turbine generator, a bag house filter, and an induced draft fan and stack (lacitysan.org 2004).

The plant has two 2.64 TPH rotary pyrolysis kilns. The outside part of the kilns reach 1,292 ^{o}F and the inside 925 ^{o}F resulting in pyrolysis of the organic portion of the MSW and the production of syngas with a residence time of 1 hour.

By-products of the pyrolysis process (char material and inorganic bottom ash) are landfilled as inert waste.

The facility is capable of producing 2.2 MW annually (or 22,473 cf/ton MSW).

G-1.2.3 Hamm Pyrolysis Plant (Hamm, Germany)

The Hamm facility has a capacity of 100,000 TPY. The $70 million facility can reportedly produce 15 MW of electricity annually. Similar to the Burgau plant, MSW feedstock requires pre-treatment to decrease particle sizes to less than 200 mm. The pyrolysis process uses natural gas to heat the pyrolysis chamber (IDeA Knowledge 2005).

G-1.2.4 Burlington Pyrolysis Plant (Burlington, Vermont)

The Burlington plant was constructed in 1998 at a cost of $52 million and has a biomass throughput of 200 tons per day (TPD). The estimated capital cost per daily ton is $260,000 (Pytlar et al. 2010).

G-1.2.5 Romoland Pyrolysis Plant (Romoland, California)

The plasma arc/pyrolysis facility in Riverside was originally built without an Environmental Impact Report and subsequently did not pass test burns conducted in 2004 on sewage sludge. In 2005, the South Coast Air Quality Management District determined that the pyrolysis facility was emitting significantly more dioxins, VOCs, and particulate matter than two existing large MSW incinerators in the LA area (Green Action 2006).

G-2 PLASMA GASIFICATION

G-2.1 OVERVIEW

Plasma technology uses an electrical discharge to heat a gas (typically air, oxygen, nitrogen, hydrogen, argon, or a combination) to temperatures above 3,800 ^{o}C. The hot ionized gas, or plasma, can then be used to treat MSW, converting them to a non-hazardous glassy slag. Because of its high heat density, high temperature, almost complete conversion of carbon-based materials to syngas, and conversion of inorganic materials to a glassy non-hazardous slag, plasma gasification has the potential to convert MSW to electricity more efficiently than conventional pyrolysis and gasification systems.

The plasma gasification process occurs in a closed, pressurized reactor, where feedstock comes into contact with hot plasma gas. There are two basic types of plasma torches – transferred torch and non-transferred torch. Plasma arc control of the gasification process becomes less efficient during startups and turndowns, when throughput is decreased.

The largest commercial-scale plant in operation is the Hitachi Metals facility in Utashinai, Japan, which uses the Westinghouse Plasma technology in two Hitachi Metals reactors to reportedly process up to 220 TPD of MSW and/or auto shredder residue using two operating torches per reactor. While there are many companies that offer plasma gasification systems, they are typically based on the plasma arc technology from only a few suppliers. The smallest system using MSW is 23 TPD and the largest is 180 TPD.

G-2.2 Plasma Gasification Facilities

G-2.2.1 Plasco Trail Road WTE Facility (Ottawa, Canada)

In 2006, Plasco Energy Group Inc. reached an agreement with the City of Ottawa to construct a commercial-scale demonstration and development MSW conversion facility co-located with the city's Trail Road Landfill site. The 100 TPD facility was constructed in 2007 at a cost estimated at $27 million and started receiving curbside collected MSW in 2008. In September of 2012, Plasco signed a 20-year contract woth $9.1 million per year to process 300 TPD of MSW at an expanded facility which could generate about 12 MW of electricity per day (betterbtuprojects.com 2012). The facility would reportedly produce 11,600 tons of slag each year.

Three types of residual waste ash are created as part of the plasma gasification process: converter ash, ash fines, and bag house ash (Plasco 2011). Ash fines are non-hazardous and disposed at the Trail Road Landfill. Bag house ash is disposed as a hazardous waste. Slag, also created during the process, is disposed at the Trail Road Landfill. It is hoped that in the future slag can be used as part of roadway construction in the area. Other miscellaneous hazardous wastes generated as part of standard operations include waste oils, lubricants, process chemicals, and filter material.

The Plasco Trail Road demonstration facility has only been operated on an intermittent basis since 2008. In 2011, the plant was only operated during late October, November, and December and processed only 770 tons of MSW reportedly due to several maintenance issues, including replacement of air inlet filters, low oil levels, replacement of the torch hydraulic unit filter, leaking drain valves, malfunctioning H_2S heat exchanger, faulty H_2S temperature gauges, malfunctioning syngas blower.

G-2.2.2 Mihama-Mikata Plasma WTE Facility (Mihama-Mikata, Japan)

Little information is available regarding the Mihama-Mikata WTE Facility in Japan. The facility, which has been operational since 2002, is operated by Hitachi Metals and reportedly processes 20 TPD of MSW and 4 TPD of wastewater sludge (AlterNRG 2013). Because the plant is relatively small, it does not produce syngas for fuel. Instead, it produces steam and hot water, which are used for power and heat generation in the industrial park (michigangreen.org). It does not appear the facility has experienced many setbacks; however, the design of the facility was similar to R&D plants and therefore did not incur potential scale-up complications.

G-2.2.3 EcoValley WTE Facility (Utashinai, Japan)

In 2003, the EcoValley WTE Facility was one of the first WTE facilities in the world to utilize plasma gasification technology on a commercial basis and scale. The facility processes up to 220 TPD of

MSW and auto shredder residue using a technology developed by Westinghouse Plasma Corp. and Hitachi Metals. Westinghouse and Hitachi began collaborating in the early 1990s leading to the construction of the R&D 12 TPD Westinghouse plasma center in Pennsylvania and a 24 TPD demonstration facility in Yoshii, Japan. After a year of operating the Yoshii facility, the Japan Waste Research Foundation certified the plasma gasification process. Hitachi Metals went on to build the EcoValley WTE facility in 2003 and the Mihama-Mikata WTE facility in 2002.

The process at the EcoValley facility involves six steps (Willis et al. 2010):

1. MSW is shredded to 2.5 inches and then mixed with auto shredder residue in a waste pit. The shredded material is then mixed with metallurgical coke and flux before input into the gasifier.
2. The shredded material is transported to the gasifier where it is heated and converted to syngas (CO, H_2, and CH_4 combustible gases, and CO_2 and N_2 non-combustible gases). Syngas exits at the top of the gasifier, while inorganic materials are melted and exit at the bottom of the gasifier as molten slag. Some of the coke is consumed, but most forms a bed onto which the shredded material falls and is gasified. The coke bed also provides voids for the molten flux, slag, and metals to flow downward and gas to flow upwards. Furthermore, the coke reacts with incoming oxygen to provide heat for gasification of the feed material.
3. The syngas is transferred to an afterburner, where it is combusted.
4. The hot gas leaves the afterburner and is conveyed to a heat recovery steam boiler where it is cooled to produce steam.
5. The steam is used to drive a steam turbine generator. The facility is rated to produce 7.9 MW (1.5 MW to the grid and the remainder utilized for the plasma reactor operation).
6. Flue gas exits the heat recovery steam boiler and is cleaned in a bag house system before being vented to the atmosphere.

The facility experienced three major problems that resulted in significant downtime and expense to fix. As a result, EcoValley was not able to process the auto shredder residue it was contracted to process, and generators were forced to find alternative disposal alternatives. EcoValley has since resolved operational issues; however, MSW feedstock in the area is already under other long-term disposal contracts. The EcoValley plant is operating at only half-capacity and therefore cost and operations are greater than revenue from electrical sales. Hitachi decided to schedule a cease to operations in 2013. Problems at the EcoValley facility are summarized below (Willis et al. 2010).

- The internal diameter of the bottom of the gasifier was initially too large. Cold spots formed, rendering the gasifier inoperable.

  Determining the correct dimensions of reactors during scale up was difficult because gas flows and heat flows were difficult to predict. The four plasma torches could not adequately heat up the entire coke bed so cold spots formed. Slag solidified in the cold spots and blocked the downward progression of feedstock in the gasifier. The problem was solved within 18 months of startup.

- The gasifier refractory did not achieve an acceptable lifespan.

  Hitachi Metals experimented with various combinations of refractories for the first two years of operation before finding a combination of inner and outer layers that were acceptable.

- Fine particulates entrained in the syngas accumulated on the walls of the refractory afterburner.

The high temperature caused particulates in the syngas to be transferred into the afterburner in a molten state. The particulates adhered to the refractory afterburner causing frequent shutdowns. Hitachi lowered the syngas exit temperature to 1,000 ^{o}C so that particulates were neither molten or ash. However, the particulates became sticky and accumulated inside the duct between the reactor and the afterburner. The slag deposits caused shutdowns and were difficult to remove.

Hitachi lowered the syngas temperature again to 700 ^{o}C so that all particulates would be carried over as ash. However, the lower temperature resulted in a lower temperature in the afterburner and the heat recovery system making the overall energy conversion process less efficient.

G-2.2.4 St. Lucie WTE Facility (Florida)

The St. Lucie plasma gasification WTE facility is currently planned. The 3,000 TPD facility reportedly costs $450 million to construct and requires a 331 acre site. At full capacity, the plant will produce 120 MW of electricity. The company Geoplasma would design, construct, and operate the facility (Northspan 2008).

G-2.3 DISADVANTAGES OF PLASMA GASIFICATION

The CCH initially contracted R.W. Beck Inc. to conduct a 2003 review of plasma arc gasification and vitrification technology for waste disposal (Beck 2003). The study was aimed at determining the feasibility of constructing a plasma arc gasification facility on Oahu for the processing of MSW. According to the study (and also discussed in other reviewed references), air emissions from plasma arc facilities would produce similar amounts of emissions as traditional WTE incineration facilities. The study furthermore questioned the technical difficulties of designing a scale-up facility when most plasma arc MSW facilities at the time were still in the R&D phase. The Beck study recommended the CCH put out a RFP to determine the capital and operating costs required to operate construct and operate a facility that would meet the CCH's MSW needs.

Conclusions drawn from a review of the RFPs are listed below (honolulu.gov 2013).

- Costs proposed were twice that of WTE facilities.
- Plasma gasification would not offer environmental advantages related to lower emissions or higher energy production compared to WTE.
- Proposals required the use of additional fuels adding to operational costs and depletion of non-renewable resources (plasma arc requires coke and plasma torch requires coke and coal).
- Landfilling of slag would still be necessary. Reuse opportunities are discussed, but none were currently being done.
- The plasma gasification process was still in the R&D phase.

G-3 DISCUSSION

As discussed in the feasibility study, incineration is often chosen for its relative simple operation, reliability, and ability to process a highly variable mixed waste stream. Two other WtE technologies, pyrolysis and gasification, were evaluated in this appendix and were found to have significantly greater financial risk and up-front capital costs. Although the pyrolysis and plasma gasification processes have been in use for several years, their commercial-scale operation of MSW is still nascent. As demonstrated at the GEM, Eco-Valley, and Plasco facilities, scale-up issues can lead to major problems potentially rendering the plant inoperable. Furthermore, the pyrolysis and plasma gasification processes are not zero-waste technologies and will produce waste materials (e.g., slag, carbon char, ash) that typically are managed through landfilling.

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AECOM Technical Services, Inc.
1001 Bishop Street, Suite 1600
Honolulu, Hawaii 96813
T 808.523.8874
F 808.523.8950
www.aecom.com