

Engineering Design and Operations Plan (EDOP)
Denver Zoological Foundation
Waste To Energy System



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Confidential Business Information

Denver Zoological Foundation, Inc., a Colorado nonprofit corporation ("**DZF**") has developed a proprietary system and methodology that may be used to convert waste to energy (the "**DZF Waste-to-Energy System**"). The DZF Waste-to-Energy System encompasses a gasification system, and related software and other analytical tools, models, processes and approaches, all developed and designed by and owned by DZF. As of the date of this Engineering Design and Operation Plan ("**EDOP**"), DZF has filed a utility patent with respect to certain ideas and inventions embodied in the DZF Waste-to-Energy System, [*International application No. PCT/US2012/024555, PCT Application No. PCT/US2012/024555 Entitled "SYSTEMS AND METHODS FOR WASTE COLLECTION, PROCESSING, AND OPTIMIZATION, BIOMASS FUEL GENERATION, AND GASIFICATION" in the Name of Denver Zoological Foundation, Inc.*], and additional patent application filings may be made after the date of this EDOP. However, a significant portion of ideas, inventions, techniques, modifications, processes, improvements and other intellectual property rights associated with the DZF Waste-to-Energy System are protectable under law, and are protected by DZF, as trade secrets and other proprietary and confidential business information and materials (collectively, "**Confidential Business Information**" or "**CBI**"). Public disclosure of DZF's Confidential Business Information, as well as any unauthorized disclosure or use of DZF's confidential information, would be detrimental to, and cause significant damage and harm to, DZF.

To protect DZF's Confidential Business Information, this EDOP has been prepared by DZF to provide the information that is required by Colorado Department of Public Health and Environment ("**CDPHE**") requirements 6 CCR 1007, part 2, without inclusion of Confidential Business Information of DZF. If CDPHE determines that access to, and review of, DZF's Confidential Business Information is necessary for approval of this EDOP, DZF and CDPHE will make separate arrangements for limited access to, and review of, such Confidential Business Information pursuant to arrangements that are agreed between DZF and CDPHE and maintain DZF's protection of its Confidential Business Information. No materials containing DZF Confidential Business Information that are shared with CDPHE will be attached to this EDOP or maintained in or with any CDPHE records.

Introduction

Denver Zoological Foundation, Inc. is a private Colorado nonprofit corporation that was formed in 1950 to, among other things, develop, manage and operate the 80-acre property known as the Denver Zoological Gardens located at 2300 Steele Street, Denver, CO 80205 in Denver's City Park (the "**Denver Zoo**") in collaboration with the Denver Parks and Recreation Department on behalf of the citizens of the City and County of Denver (the "**City**") and the State of Colorado. DZF presently, among other things, develops, manages and operates the Denver Zoo pursuant to a cooperative agreement with the City. DZF is governed by an elected Board of Trustees comprised of community and business leaders.

The mission of DZF is to secure a better world for animals through human understanding. As of the date of this EDOP, (a) the Denver Zoo is the most popular cultural attraction in Colorado, (b) the Denver Zoo is consistently ranked as one of the most popular zoos in the United States and features a diverse animal collection, (c) DZF participates in more than 40 Species Survival Plans (SSPs), cooperative breeding and conservation programs dedicated to sustaining populations of endangered species, and (d) DZF supports

75 field conservation and research projects in 22 countries.

A leader in environmental action, DZF is dedicated to ensuring the safety of the environment in support of all species. Denver Zoo is the first U.S. zoo to receive ISO 14001 certification for the entire zoo facility and operations. This international certification ensures that DZF is attaining the highest environmental standards at Denver Zoo. Through the operation of DZF's Sustainable Management System ("**SMS**"), DZF is committed to conducting business in manner that meets or exceeds environmental regulations and policies and reducing Denver Zoo's operational impacts on the environment through continual improvement.

One of the major goals embedded in DZF's SMS, is to become a zero waste operation at Denver Zoo by 2025. This will be accomplished through the implementation and use of the DZF Waste-to-Energy System at Denver Zoo. The DZF Waste-to-Energy System to be implemented at Denver Zoo will be located in the Waste Management Building in Denver Zoo's new Toyota Elephant Passage (TEP) exhibit. DZF will use the DZF Waste-to-Energy System to convert waste generated on-site at Denver Zoo into energy for on-site heat and power. The DZF Waste-to-Energy System to be implemented at Denver Zoo is sometimes referred to in this EDOP as the "**Denver Zoo Waste-to-Energy System.**"

The DZF Waste-to-Energy System utilizes the technology of gasification. Gasification is a process that thermally converts organic materials into hydrogen, carbon monoxide, and methane. This is achieved by thermally reacting the solid fuel at high temperatures (>700°C) with a reactant, the oxygen present in outside air, and controlling the thermo chemical reactions to produce a combustible gas. The resulting gas mixture is called producer gas or *syngas* (from *synthesis gas* or *synthetic gas*). The power derived from gasification of zoo waste and combustion of the resultant syngas is considered to be a source of renewable energy. The energy to be produced by Denver Zoo from gasification will be used to power approximately 20% of total zoo energy needs, including residual heat that will be used to provide hot water needs within the new Toyota Elephant Passage (TEP) exhibit.

Ultimately, the Denver Zoo Waste-to-Energy System will take 90% of Denver Zoo's waste stream and convert it into energy and heat, which will result in an estimated savings to DZF with respect to its management and operation of the Denver Zoo of approximately \$150,000 a year in energy costs and a reduced landfill footprint of approximately 1.5 million pounds per year. The Denver Zoo Waste-to-Energy System is a serious step toward DZF's goal of zero waste operation at Denver Zoo by 2025.

This EDOP is prepared in support of DZF's application for a Certificate of Designation (CD) for the waste handling and solid fuel development portion of the Denver Zoo Waste-to-Energy System, pursuant to CDPHE requirements 6 CCR 1007, part 2, and more specifically, section 11 of such part 2. See section titled "Confidential Business Information" above for further detail as to DZF's treatment of its confidential business information in connection with this EDOP. This EDOP includes the personnel guidelines developed by DZF for the operation and maintenance of the waste handling and solid fuel development portion of such Denver Zoo Waste-to-Energy System. This EDOP includes minimal

operational information for the Denver Zoo Waste-to-Energy System at the point of energy generation as that process is covered in the separate air permit operations application materials. Some general assumptions and information is included for reference and to meet the intent of section 11 of CDPHE requirements 6 CCR 1007, part 2.

11.2.1 General Information

(A) Table 11.2.1

Name		Denver Zoological Foundation, Inc.
Address (Physical)		2900 E 23 rd Ave. Bldg #31108, Denver, CO 80205 City Park, City and County of Denver
Mailing Address		2300 Steele Street, Denver, CO 80205
Telephone number (Operations)		720.337.1500
Site Manager	George Pond Vice President of Design and Campus Management	Phone: 720.337.1496 Email: gpond@denverzoo.org
Denver Zoo Waste-to-Energy System Manager	Paul Quick Director of Special Projects	Phone: 720.317.2995 Email: pquick@denverzoo.org
Environmental Regulatory Contact	Jennifer Hale Director of Safety and Sustainability	Phone: 720.337.1558 Email: jhale@denverzoo.org

(B) Table 11.2.1 Site Location

Legal Description:	TS 35 R68W NW ¼ section 36
County	Denver
Geographic Coordinates:	39°45'N 104°57'W
Mailing Address:	2300 Steele Street, Denver, CO 80205
Phone number:	720.337.1500 (Operations)

(C) Area of Site (see drawing C-0: Vicinity Map)

The Denver Zoo campus encompasses approximately 80 acres (including parking lots) in City Park in the City and County of Denver, Colorado, and has the geographical coordinates of 39°45'N 104°57'W. The Waste Management Building, which includes the waste handling and solid fuel development operations for the Denver Zoo Waste-to-Energy System, is located within the new 10-acre Toyota Elephant Passage (TEP) exhibit located on the south management boundary of Denver Zoo, adjacent to Duck Lake in City

Park. The Denver Zoo is bounded on all sides by City Park, which is owned by the City and County of Denver and managed by the City's Department of Parks and Recreation.

(D) General Description of Facility (see drawing C-1: Area/Topo and A-0: Plan View)

The Denver Zoo Waste-to-Energy System will be located at the Waste Management Building located inside the new Toyota Elephant Passage (TEP) exhibit at Denver Zoo. The Denver Zoo Waste-to-Energy System will be managed and operated by DZF personnel, specifically DZF's Facilities Group under the direction of DZF's Vice President of Design and Campus Management. The general description of the "facility," for purposes of section 11 of CDPHE requirements 6 CCR 1007, part 2, is identified in drawing C-1 and is specifically the footprint of the Waste Management Building. Waste is collected in designated carts, bins and receptacles located on zoo grounds (both operations waste and guest waste). Collection bins and carts are typically housed adjacent to the exhibits, office buildings, and guest pathways within Denver Zoo. Waste is sorted through staff and guest training, and through designated bins located within Denver Zoo that identify those items of waste that can be used to develop a solid fuel for the Denver Zoo Waste-to-Energy System. Approved waste will be collected and transported from bin and cart locations within Denver Zoo to the Waste Management Building on a daily basis. DZF's grounds personnel are responsible for the collection and transportation of waste within Denver Zoo, including to the Waste Management Building. DZF's grounds personnel currently include personnel employed by DZF, as well as certain City employees assigned to Denver Zoo that are managed and supervised by DZF in accordance with the cooperative agreement between DZF and the City.

All equipment associated with the Denver Zoo Waste-to-Energy System will be contained within the Waste Management Building, except for a small component of the system which will be secured under a partially enclosed overhang attached to the Waste Management Building. There are two un-covered storage areas that will be used primarily for temporary storage of dry wastes. DZF will maintain on site adjacent to the Waste Management Building an existing large scale landfill compactor and oversized roll off for management of non-fuel based materials and emergency back-up.

(E) Discussion of Facilities Service and Transportation Corridors (see drawing C-1: Area/Topo)

Denver Zoo is centrally located within the City Park boundaries. City Park is adjacent to residential neighborhoods on all sides, including the neighborhoods of Park Hill, Skyland, Whittier, and City Park West. City Park resides between the major cross streets of E 17th Avenue and E 23rd Avenue to the north and south, and York Street and Colorado Avenue to the west and east.

The Waste Management Building (see drawing C-1) is located in the southwest corner of the Denver Zoo, within the new 10-acre Toyota Elephant Passage (TEP) exhibit. The Waste Management Building can be seen from the adjacent Duck Lake boundary on the west side of City Park.

DZF will use park roads within City Park to access the nearest Denver Zoo perimeter gate (Gate #15) located adjacent to the Waste Management Building. This access point will be used to transport equipment, approved outside waste materials (see note below), and hauling of the existing compactors and oversized roll off. *Note regarding approved outside waste materials* - Currently, the only approved

outside waste material is urban forest residue from Denver Parks and Recreation. This is the only acceptable waste that will be accepted by Denver Parks and Recreation due to zoning restricted use as described in Appendix B. If DZF seeks to add additional outside waste sources in the future, DZF will submit an EDOP amendment for approval at such time. The access point described in this paragraph would be the access point for any such additional approved outside waste materials. A copy of DZF's Waste Acceptance Plan is provided in Appendix K.

Transportation of zoo waste materials inside the perimeter fence will continue to be transported as it is today via the zoo's internal pathways. DZF's grounds personnel manages the collection and transportation of all pre-sorted trash bins and carts, by using a gas powered Jeep or electrical carts. Transportation typically occurs before visitation hours for Denver Zoo guests. DZF's grounds personnel currently include personnel employed by DZF, as well as certain City employees assigned to Denver Zoo that are managed and supervised by DZF in accordance with the cooperative agreement between DZF and the City.

(E .1) Site Access (see drawing C-1: Area/Topo)

Site access to the Waste Management Building will be limited to (1) DZF employees, (2) City employees assigned to Denver Zoo that are managed and supervised by DZF in accordance with the cooperative agreement between DZF and the City, (3) DZF-approved contractors that have received DZF-approved training on the Denver Zoo Waste-to-Energy System operations and any related safety protocols and (4) certain invitees of DZF as described in the next paragraph. The entire Denver Zoo grounds are patrolled on a 24 hour basis to ensure further site safety. The Waste Management Building will only be accessible from the newly installed zoo gate #15 and from the Toyota Elephant Passage (TEP) exhibit Service Road. There will be no public access to the Waste Management Building.

DZF will likely maintain some points of access to conduct site specific tours of the Waste Management Building. Any tours in this area will include a DZF employee as an escort. It is likely that during operation of the Denver Zoo Waste-to-Energy System, DZF-authorized tours will need to be scheduled in coordination with DZF's Facilities Group staff (specifically, the staff with management and operational responsibilities for this system) to ensure site safety.

(F) Listing of all Permits or Construction Approvals (see drawing C-0)

This Section 11.2.1 (F) describes the permits for the Denver Zoo Waste-to-Energy System that have been received or applied for by DZF at the time of the application for the Certificate of Designation. Such permits are identified in Table 11.2.1 (F) below. As to any other permits that may be applied for or obtained after the Certificate of Designation is issued (and that will not be issued by the City), DZF will keep the City informed of such pending permits and will provide, the associated analytical, process change and other pertinent information relating to the permit (provided that if any such information constitutes CBI, the CBI portion of such information will only be provided if DZF and the City have entered into a nondisclosure agreement for the protection of the CBI portion of such information). A copy of all final permits for the Denver Zoo Waste-to-Energy System will be sent to the City's Department of Environmental Health (DEH) for filing in their records.

(1) Water Quality Permits

(a) *General Site Stormwater Discharge:* All non-direct discharge of stormwater (example: general site sheet flow) within Denver Zoo is managed under the City's Municipal Stormwater (MS4) permit program. DZF's existing MS4 permit is Permit # COS-000001, issued on March 1 2009 (a copy of this permit is included in Appendix D).

(b) *Construction Activities Stormwater Discharge:* The Denver Zoo Waste-to-Energy System will be located at the Waste Management Building located inside the new Toyota Elephant Passage (formerly Asian Tropics) (TEP) exhibit at Denver Zoo. The TEP exhibit project involved ten acres of redevelopment and construction of multiple structures, including the Waste Management Building. The Waste Management Building was permitted through the City's Building Department in 2008 and was constructed in 2012. DZF and the General Contractor of the TEP exhibit project procured all identified, necessary stormwater construction permits (CDPHE Construction Activities Stormwater Discharge Permit, #COR03F894). The management of the stormwater construction permit was transferred to DZF in July 2012, and closed out by both CDPHE and City in fall of 2013. A copy of this permit is included in Appendix D of the EDOP.

(c) *Permanent Dewatering:* DZF manages a site groundwater dewatering system associated with an adjacent building to the Waste Management Building under CDPHE Subterranean Dewatering Permit (#COG603179). A copy of this permit is included in Appendix D of the EDOP.

(d) *Industrial Permit for Water:* See discussion of wastewater discharge permits in Section 11.2.1 (F)(3) below.

(2) Air Quality Permits

Although CDPHE is the regulatory agency that will issue any required air quality permits for the Denver Zoo Waste-to-Energy System, the City, through the Environmental Quality Division (EQD) of DEH, participates in air quality control by conducting inspections of the Denver Zoo Waste-to-Energy System (once it is operational) for compliance with state and federal laws, state air pollution permits and local city ordinances.

DZF has submitted to the Air Pollution Control Division of CDPHE drafts of an Air Pollutant Emission Notice (APEN) and Application for Construction Permit (draft permit #12DE2647) for the operation of the Denver Zoo Waste-to-Energy System, including all associated equipment operations from material handling, gasification, and energy generation. Copies of the permit application materials have been provided to the Denver Department of Environmental Health (DEH), and DZF will keep DEH informed as to this pending permit and ongoing discussions with CDPHE. Further, DZF will comply with the additional permit procedures set forth in the introductory paragraph of this Section 11.2.1 (F).

DZF will need to obtain, in consultation with the Air Pollution Control Division of CDPHE, a Title V operating permit for Denver Zoo's Waste-to-Energy System. All of the necessary changes have been submitted to CDPHE. These updated APEN's meet the requirements associated with 40 CFR 60 Subpart EEEE (determination for applicability through meetings with region 8 EPA). DZF will keep DEH informed as to its ongoing discussions with CDPHE and the permitting process for the Title V operating permit. Further, DZF will comply with the additional permit procedures set forth in the introductory paragraph of this Section 11.2.1 (F).

(3) Local Wastewater/other Permits

(a) *SUDP*: DZF obtained the necessary Sewer Use and Drainage Permit (SUDP) from the City for the Waste Management Building (# 200910118). A copy of this permit is included in Appendix D of the EDOP.

(b) *Stormwater Discharge Permits*: See Section 11.2.1 (F)(1) above.

(c) *Dewatering Permit*: See Section 11.2.1 (F)(1) above.

(d) *Wastewater Discharge Permit*: DZF continues to evaluate, in consultation with the Water Quality Control Division of CDPHE and Metro Wastewater, whether the Denver Zoo Waste-to-Energy System will generate wastewater that is subject to regulation and permitting under applicable Federal, state or local wastewater regulations. A final determination cannot be made until the Denver Zoo Waste-to-Energy System is operational at the Waste Management Building and data pertaining to generated liquid waste is available. DZF will keep the City informed as to its ongoing discussions with CDPHE and Metro Wastewater as to the wastewater regulations and any necessary permit(s). If it is determined that an additional permit will be obtained by DZF, DZF will comply with the additional permit procedures set forth in the introductory paragraph of this Section 11.2.1 (F).

(e) *Building-Associated Permits*: All other building-associated permitting with respect to the Waste Management Building will be obtained through the City Building Department as DZF begins to install equipment. These permits may include but are not limited to electrical, mechanical, plumbing, and fire suppression.

(f) *Reclaimed Water Authorization*: DZF was issued a Notice of Authorization (NOA) for Denver Zoo from CDPHE for the "Use of Reclaimed Water" (permit # COE012006). A copy of this NOA is included in Appendix D of the EDOP.

(g) *Beneficial Use Designation (Ash and other Waste Byproducts)*: See discussion in Section 11.2.3(K) of the EDOP.

Table 11.2.1 (F) Permitting and Construction Approvals

Permit type	Regulatory Agency	Permit Number	Issuance Date
Permits Described in Section 11.2.1 (F)(1) (Water Quality)			
MS4- general site stormwater discharge	CDPHE/ City	COS-000001	3/1/2009
Construction Activities Stormwater Discharge Permit	CDPHE City	COR03F894 201001028	Transferred to Denver Zoo 7/10/2012 Closed 9/30/2013 & 10/2/2013
Permits Described in Section 11.2.1 (F)(2) (Air Quality)			
Air Pollutant Emission Notice (APEN) and Application for Construction Permit	CDPHE & City	12DE2647	DRAFT
Permits Described in Section 11.2.1 (F)(3) (Wastewater/other Permits)			
Sewer Use and Drainage Permit (SUDP)	City	200910118	5/21/2010

Notice of Authorization (Use of Reclaimed Water)	CDPHE	COE012006	4/23/2013
Subterranean Dewatering Permit	CDPHE	COG603179	9/5/2013 (renewal)

Appendix D

Copies of the permits listed in Table 11.2.1 (F) are included as Appendix D to the EDOP. Appendix D to the EDOP may be further supplemented after the date of this EDOP to include additional permits obtained by DZF for the Denver Zoo Waste-to-Energy System.

11.2.2 Maps and related information

(A) Topographical Map (see drawing C-1: Area/Topo Map)

The current owner of the property at which the Denver Zoo is located is the City and County of Denver. DZF develops, manages and operates the Denver Zoo pursuant to a cooperative agreement with the City. There are some internal park roadways to the Denver Zoo and the closest roadway to the Waste Management Facility is through Gate 15 on the south side of the zoo property boundary. See drawing C-0 for more details on topography around the Waste Management Building.

(B) Other Major Maps and documentation

(1) Land use, Zoning, Population densities (See drawing C-0)

Denver Zoo is zoned OS-A, open space with a maximum building height/minimum zone lot size of 3,000 sq ft. DZF develops, manages and operates the Denver Zoo in collaboration with the City's Parks and Recreation Department on behalf of the citizens of the City and the State of Colorado pursuant to a cooperative agreement with the City. Population density surrounding the facility within one square mile increments range from 4,000 – 10,000 people/square mile.¹

(2) Regional site drainage conditions (see drawing C-2: Drainage and Wastewater)

(a) Overview of Regional Site Drainage Conditions. The Waste Management Building is located at an elevation of 5,275 feet. The overall Denver Zoo campus is a heavily-managed, wooded urban area. Elevation changes are gradual throughout the entire campus and the topography gradually slopes from the northeast to the northwest corner of the zoo, located adjacent to E 23rd Avenue.

The Waste Management Building located on the southwest corner of Denver Zoo is adjacent to Duck Lake in City Park. City Park is owned by the City and managed by the City's

¹ <http://www.city-data.com/city/Denver-Colorado.html>

Department of Parks and Recreation. The site topography around the Waste Management Building is shown in drawing C-2: Area/Topo Map.

The floodplain designation for the site area where the Waste Management Building is located is referred to as Zone X (shaded). The Federal Emergency Management Agency (FEMA) definition for a Zone X area is:

	DESCRIPTION
B, X (shaded)	Moderate risk areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than 1 foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1-percent-annual-chance flood by a levee. No BFEs or base flood depths are shown within these zones. (Zone X (shaded) is used on new and revised maps in place of Zone B.)

(b) Stormwater Management. The Waste Management Building was designed to cover and contain all equipment and material handling areas from coming in contact with stormwater. Stormwater runoff from the building roof is directed away from the building and into an adjacent porous landscape detention basin (PLD). Drawing C-2 (Drainage and Wastewater) shows the location of the PLD (PLD G) adjacent to the Waste Management Building. All stormwater collected in the Toyota Elephant Passage (TEP) site goes through a series of porous landscape detention basins before being discharged via storm drains, and at PLD G via groundwater. This general stormwater flow from the site is managed under the City's Municipal Stormwater (MS4) permit #COS-000001. DZF also manages a site groundwater dewatering system associated with an adjacent building to the Waste Management Building under CDPHE Subterranean Dewatering Permit (#COG603179). See Section 11.2.1 (F) of the EDOP for additional information as to the permits for the Denver Zoo Waste-to-Energy System.

(c) Additional Information Related to Duck Lake.

(i) Engineering Controls Within and Outside of the Waste Management Building. The Waste Management Building located on the southwest corner of Denver Zoo is adjacent to Duck Lake. See Drawing C-2: Area/Topo Map. As a result of the close proximity of the Waste Management Building to Duck Lake, numerous engineered controls exist both within and outside of the Waste Management Building to minimize spills or releases of liquids that are used during, or result from, the waste-to-energy conversion process from entering Duck Lake.

(1) A 1,792 cubic foot, subgrade, waterproof, concrete press pit is located in the covered overhang area (reference Drawing P-1, below equipment #1-4), dedicated to collecting any runoff liquids from the waste sorting process. There is a 3" corner drain in the bottom of this press pit. See further discussion of the drain system in paragraph (4) below.

(2) A 1,801 cubic foot, subgrade, waterproof, concrete ash pit resides within the Waste Management Building (below equipment #8-1, 8-2, and 8-3), dedicated to collecting any ash generated during the waste-to-energy conversion process. There is no floor drain in the bottom of this ash pit. This indoor "ash vault" will be utilized to only collect and temporarily store (before disposal) of ash. The vault is sealed by 12" concrete coated with cement waterproofing "Xypex" material. Ash will not be moved or stored anywhere else on-site as to eliminate the possibility of any spills to the environment. All ash will be handled and disposed of as described in Section 11.2.3 (K) of the EDOP.

(3) DZF is currently working on the design of a secondary containment structure to be built around the 10,000 gallon glycol/water tanks located inside the north end of the Waste Management Building. Once the design plans are complete, the EDOP will be amended to include the relevant engineering figures and calculations for the construction of this secondary containment structure and to demonstrate the ability of such structure to capture accidental releases of liquids from the tanks. Denver Zoo will add monthly inspection of the secondary containment and tanks to a preventative maintenance schedule. In the unlikely event that spilled fluids from the glycol tank escape the secondary containment structure, these fluids could be discharged to a sanitary system through a floor drain located on the north side of the Waste Management Building. Any released fluids would enter a sand oil interceptor first before transportation to private sanitary line, then private sanitary lift station located on the Denver Zoo grounds. Denver Zoo will notify Metro Wastewater in the event that glycol materials are released to the sewer.

(4) All areas within the Waste Management Building proper and under the covered overhang area (reference Drawing P-1, below equipment #1-4) are sloped to drain toward floor drains. In total, there are seven 3" floor drains – three inside and four under the covered overhang. All of these floor drains lead to a 330 gallon sand-oil interceptor, a 6" dia. private sanitary system, private sanitary lift station, and ultimately discharge into the municipal sanitary system. The City approved this discharge under Sewer Use Discharge Permit #200910118. The collection and flow to the sanitary systems through the Sand/Oil interceptor (S-OI) can be seen in Drawing P-1 and Drawing C-2 (Drainage and Wastewater). See also Section 11.2.1 (F) of the EDOP for additional information as to the SUDP and other permits for the Denver Zoo Waste-to-Energy System.

(ii) Duke Lake PLD Program. The PLD (PLD G) adjacent to the Waste Management Building is shown on Drawing C-2 (Drainage and Wastewater) and runs along the adjacent Duck Lake. DZF will manage a PLD inspection and corrective action program for this PLD (the "Duck Lake PLD Program") through DZF's Sustainable Management System (SMS). DZF maintains the SMS to manage DZF's environmental practices and procedures on site at Denver Zoo; the SMS received ISO 14001 certification in 2009. The procedures and records for the Duck Lake PLD Program will be maintained in accordance with DZF's SMS guidelines. The SMS policy and guidelines for the Duck Lake PLD Program will be made available to the City for review and input, including for the purpose of confirming that the Duck Lake PLD Program incorporates the Stormwater Quality Best Practice Management (BMP) Implementation Guidelines that are included in the City's Denver Water Quality Management Plan.

(iii) Spill Prevention, Control and Countermeasure (SPCC) Plan. The development and operation of the Denver Zoo Waste-to-Energy System does not currently require adoption by DZF of a Spill Prevention, Control and Countermeasure (SPCC) Plan with respect to the Denver Waste-to-Energy System. However, DZF is separately developing and will implement a SPCC Plan with respect to the diesel emergency generator that is installed in the new Toyota Elephant Passage (formerly Asian Tropics) (TEP) exhibit at Denver Zoo. DZF has expanded the scope of such SPCC Plan to cover all oils on Denver Zoo grounds greater than 55 gallons. "Oil" is defined as oil of any kind or in any form including, but not limited to, petroleum, fuel oil, sludge, oil refuse and oil mixed with wastes other than dredged spoil and oily mixtures. This also includes non-petroleum oils, synthetic oils, animal fats, oils and greases, and vegetable oils. Such SPCC Plan is being prepared and will be implemented in consultation with the City.

With respect to the waste-to-energy conversion that will occur at the Waste Management Building, Table 11.2.3 (C2) (Material Storage Schedule) identifies certain materials that constitute oils. At this time, the greatest volume of oil that is present in the Waste Management Building is a 30 gallon hydraulic reservoir associated with Equipment #1. DZF's SPCC Plan for Denver Zoo will be updated if and when oil volumes in the Waste Management Building meet the reporting thresholds to be included in the SPCC. Whether or not the oil products inside the Waste Management Building are subject to the SPCC Plan, the Equipment that will hold oil products inside the Waste Management Building will have secondary containment.

(3) Counties and municipalities – (see drawing C-0)

The proposed Waste Management Building is within the City and County of Denver.

(4) Locations of Barriers, fences, and other similar structures– (see drawing C-1)

The boundary of Denver Zoo as established by the cooperative agreement between DZF and the City is near the edge of the Waste Management Building and passes along the southwest side of the building and proceeds across Duck Lake.

(5) Solid Waste Storage and Loading Areas—(see drawing M-1: Mechanical Plan)

(6) Location of scales and weigh systems – (see drawing M-1: Mechanical Plan)

DZF has two locations at the Denver Zoo for weighing materials. One area is for material as it is brought into the system. The second in line is live bottom storage bins located under the feet of equipment #1-7 (A-C).

(7) Location, size and use of buildings and related facilities – (see drawing A-0 through A-2)

The Waste Management Building is an existing structure, which was permitted through City and County of Denver Building Department as part of the Toyota Elephant Passage (formerly Asian Tropics) exhibit in 2008.

The Waste Management Building main level is 3,000 square feet, with additional outdoor covered bulk storage areas of approximately 1,631 square feet. The plan view dimensions of the Waste Management Building are provided in drawing A-2 View Tipping Floor-.

Table 11.2.2 (B-7) Building Area

Main Level Area/inside	3,000 S.F.
Mezzanine Area	142 S.F.
Outdoor covered area	1,631 S.F.
Total Building	4,773 S.F.

The Waste Management Building foot print includes an 8 foot sloping ash vault for the collection of ash generated from the gasification system portion of the Denver Zoo Waste-to-Energy System. In addition, the outdoor processing area adjacent to the Waste Management Building includes a vault in the outdoor covered processing area to collect any liquids generated from Equipment #1-3.

(8) Utilities (See drawing E-1 Wiring Schematic and drawing P-1: Piping Diagram)

Electrical service for the equipment will be provided by a 600 Amp/480V Panel located in the northwest corner of the Waste Management Building.

Potable water service is provided to the building via a ¾" domestic service line that is specifically used in the office. Recycled water is supplied to the building for non-potable use through a 1 ¼" service line.

Natural gas service is being worked on with Xcel Energy, but currently the design load for natural gas to supplement the energy generation side for the generator will be provided by an approximate 3" gas line delivering up to 7 MMBtu/hr.

(C) Construction Plans – (see drawings A-0 through A-2)

DZF has provided with this EDOP copies of the final construction plans for the Waste Management Building Drawing.

The Waste Management Building is an existing structure, which was permitted through City and County of Denver Building Department as part of the Toyota Elephant Passage (formerly Asian Tropics) exhibit in 2008.

11.2.3 Engineering Design Information

(A) Waste Stream Information (see drawing M-1)

In order to meet DZF's goal to be zero waste at the Denver Zoo by 2025, DZF has extensively studied the waste generated on-site at Denver Zoo and feels confident that 90% of such waste can be developed into a viable solid fuel product with the Denver Zoo Waste-to-Energy System. There are some waste types that do not meet DZF's standards for development into a solid fuel and will be managed accordingly in order to either comply with regulatory standards for disposal of such waste, or, in the case of waste that is recyclable, continue to support recycling efforts in the community.

DZF currently sorts waste generated at Denver Zoo into categories. Wastes generated in these categories have been tracked using a built in scale and numbering system on our collection system from 2006-2010. The evaluation of waste included tipping and weighing dumpsters throughout the zoo and then using a combination of results gathered with approximations attained from visual sampling to derive the following statistics based upon a weight percentage.

There are currently 48 one yard dumpsters in the Denver Zoo in use throughout the year. There are also currently 212- 25 gallon green guest waste containers throughout the zoo. Using a combination of visual and volumetric sampling with densities, DZF provided approximations for seasonal fluctuations in waste generated on zoo grounds. These volumes and represented waste handling categories are broken down into the following tables that will be used for operational tracking of waste.

Although the waste processed in the waste to energy facility will come primarily from waste generated at Denver Zoo (guest and operations), it will also include urban forest residue from Denver Parks and Recreation. This is the only acceptable waste that will be accepted by Denver Parks and Recreation due to zoning restricted use as described in Appendix B. If DZF seeks to add additional outside waste sources in the future, DZF will submit an EDOP amendment for approval at such time. A copy of DZF's Waste Acceptance Plan is provided in Appendix K.

Table 11.2.3 (A-1) Waste Categories

Waste categories	Yearly Estimates in Tons (based on 2006-2010 data)	Processing Category	Description
Mixture of biomass and operations waste	1200-1400	FUEL	Material that can be beneficially processed into a viable solid fuel and has an energy value, defined as the heating value for a given "biomass".
Paper/cardboard	50-75		
Urban forest residue from Denver Parks and Recreation	1000-1200		
Recycling	30-40	RECYCLING	Material that cannot be beneficially processed into fuel and will continue to be recycled through DZF's existing recycling contract service. This category also includes management waste streams categorized as Universal Waste and managed with City and County of Denver through recycling programs. This includes but not limited to: batteries, aerosol cans, CFLs, fluorescent light bulbs, mercury containing devices.
Universal and/or Hazardous Waste materials	> 1		
Landfill wastes	100-200	LANDFILL	Any materials that currently cannot be beneficially processed into fuel, does not have a recycling option within state of Colorado. These include, but are not limited to: construction generated waste, maintenance related waste, and some PVC plastics. Additionally, small quantities of hazardous waste are managed under this category. These wastes are not land filled but managed in accordance with applicable regulations for proper disposal and management.

Waste materials that fall under the landfill category will be monitored by DZF personnel in order to assess options for future recycling opportunities, or new product purchasing opportunities. This monitoring activity is in support of meeting DZF's target to be zero waste at Denver Zoo by 2025.

DZF expects seasonal variance in waste sources generated at Denver Zoo. Summertime visitation generates higher volumes of plastics, food waste, and cardboard for concessions.

Table 11.2.3 (A-2) Seasonal variability

Waste Category	Estimated Summer Mix %	Estimated Winter Mix %
Mixture of biomass and operations waste	50%	53%
Paper/cardboard	3%	3%
Urban forest residue from Denver Parks and Recreation	45%	43%
Recycling	2%	1%
	100%	100%

Since the Denver Zoo Waste-to-Energy System is not yet operational at the Waste Management Building at Denver Zoo, actual data on BTU value is not yet available. This information provided below is based on a preliminary study conducted by DZF between 2008 and 2010 prior to construction of Denver Zoo’s Toyota Elephant Passage (TEP) exhibit. The results of DZF’s study were combined with data from outside sources to provide the estimated data shown below in the Table 11.2.3 (A-3). The values represented below are estimated BTU values for the refused derived solid fuel.

Proximate and Ultimate Analyses were performed by Hazen and Huffman Laboratories. The data for High Heating Value (HHV) is provided based upon the composition of the material. This provides gross components of the material, such as moisture, volatile matter, ash, and fixed carbon. The volatile data from heating the solid fuel in a controlled environment (using ASTM E-872) determines the heat rate and the energy content of the fuel by monitoring the flame temperature. Using this laboratory data combined with existing available data found from the Energy Research Centre of the Netherlands (ECN)’s Phyllis database we estimated approximate statistical evaluation of materials with zero moisture to compare calculated data versus laboratory data to confirm the initial energy value calculations.

Table 11.2.3 (A-3) Proximate/Ultime Analysis for Solid Fuel Mixture

Sample Description	Range HHV (Btu/lb)	Moisture (% wt)
Summer Material Mix (no added animal food waste)	5172-7260	0-30.78
Winter Material Mix (no added animal food waste)	6138-6459	5.3-9.46

(B) Description of Mechanical Components (see drawing M-1)

A mechanical equipment schedule and description of the building mechanical components for the Denver Zoo Waste-to-Energy System is provided in drawing M-1.

Drawings M-O and M-1 show the overall equipment layout, external and internal, for the Denver Zoo Waste-to-Energy System at the Waste Management Building.

Additional detail as to the mechanical components of the equipment comprising the Denver Zoo Waste-to-Energy System is Confidential Business Information of DZF. See section above titled "Confidential Business Information."

(C) Material Storage (see drawing M-1)

The Denver Zoo Waste-to-Energy System will have the following expected/planned material storage areas for materials to be recycled, disposed or processed into a fuel as a portion of the feedstock. This includes items that are bulky, unmarketable or noncombustible. The Items labeled woodchips and bulk storage are used to store primarily wood waste and tree trimmings. Any of Denver Zoo's existing waste streams identified as universal or hazardous waste will be managed in the same manner as they are today. All universal and hazardous materials are contained in labeled containers ranging in size from 14 gallon buckets to 50 gallon drums, and are currently located at the Stone Garage in Denver Zoo's Operations Building area. A copy of DZF's current Regulated Waste Map for Denver Zoo is provided in Appendix H of this EDOP.

Transportation, handling and disposal of ash is stated in Section 11.2.3 (K)(1) of the EDOP. Management of any scrubber residues or other liquid wastes is described in Section 11.2.3(K)(2) of the EDOP. See also Section 11.2.2 (B)(2)(c), which discusses engineering controls and other plans and programs used to minimize spills or releases of liquids that are used during, or result from, the waste-to-energy conversion process from entering Duck Lake in City Park, which is adjacent to the Waste Management Building.

The timeframes listed in Table 11.2.3 (C1) (Pre-Process and Off CD Site Storage) are planned.

Table 11.2.3 (C1) Pre-Process and Off CD Site Storage

Type of Material	Max Store (days)	Min Store (days)	Max Storage Volume		Weight (estimated)		On CD Site
Oversized/metal containing/PVC/etc materials and other non-combustibles	14	7	30	yd ³	16,200	lb	Yes
Recycled (primarily metals, glass, some plastics)	14	7	30	yd ³	540	lb	No
Metals recycling	35	21	15	yd ³	1,500	lb	No
Woodchips/tree trimmings/yard waste (leaves, plant material)	20	4	50-69	yd ³	26,000	lb	Yes
Woodchip storage	30	5	50-64	yd ³	20,750	lb	Yes
Emergency back-up roll-off compactor	4	2	30	yd ³	12,000	lb	Yes

Table 11.2.3 (C2) Material Storage Schedule - Equipment

Material Storage	Type of Material	Max Store (days)	Min Store (days)	Max Storage Volume		Weight (estimated)		Type of Containment	Secondary Containment	Location
Equipment #1-2	Un-shredded as received Campus Waste	1	0.1	15	yd ³	3,703	lb	Coated Steel bin	NA	M -1 (covered)
Equipment #1-7a	Shredded 2" minus Campus waste	2	1	19	yd ³	4,724	lb	Coated Steel bin	NA	M -1 (covered)
Equipment #1-7b	Shredded 2" minus Campus waste	2	1	19	yd ³	4,704	lb	Coated Steel bin	NA	M -1 (covered)
Equipment #1-7c	Shredded 2" minus Wood trimmings, cardboard, and paper	2	1	19	yd ³	3,965	lb	Coated Steel bin	NA	M -1 (covered)
Equipment #5-0	Shredded and dried .5-.25" minus all materials	1	0.5	10	yd ³	888	lb	Coated Steel bin - sealed	NA	M -1 (covered)
Equipment #7	Pelletized .75" dia x 1-2" long all materials	10	1	10	yd ³	15,232	lb	Coated Steel bin - sealed	NA	M -1 (inside)
Equipment #8-1/8-2/8-3	Tars/acids/particulates	7	1	0.1	yd ³	25	lb	Stainless Steel container - sealed	Ash Vault	M -1 (inside)
Equipment #8-1/8-2/8-3	Pelletized material internally/some partially pyrolyzed	3	0.05	0.44	yd ³	560	lb	Stainless Steel container - sealed	Ash Vault	M -1 (inside)
Equipment #9	water/rapeseed oil/ TBD oil (92% water/8% oil)	Always	Always	625	gal	5,000	lb	TBD	Poly Curb - Fiberglass	M -1 (inside)
Equipment #11-3,11-4	50% glycol, %50 water mix	Always	Always	20,000	gal	173,400	lb	Steel Storage Tanks	concrete containment	M -1 (inside)
Equipment #11-5	50% glycol, %50 water mix	Always	Always			1,830	lb	Stainless Heat Exchanger	concrete containment	M -1 (inside)
Equipment #8 ash vault	Ash created from gasifier operation	21	28	100	yd ³	60,000	lb	Coated Concrete	Ash Vault/concrete containment	M -1 (inside)

(D) Access/Egress/Ingress (see drawings M-1, A-0, A-1 and A-2)

See Section 11.2.1-E 1 of this EDOP for a description of site access restrictions for the Waste Management Building. The orientation, interior dimensions and specifications of the tipping floor, storage area and ingress and egress there to is provided in drawings M-1, A-0, A-1, A-2.

Materials/waste enters the process through the use of a hydraulically operated fork lifting system. The lifting system will not operate without the safety doors closed and the operators are outside the caged area in front of the Equipment #1-1. The operation of the lift itself is only performed through a key pad located on the outside of the equipment safety gate.

(E) Equipment Performance (see drawing M-0 and M-1)

The table below provides general equipment identification numbers and naming for the equipment comprising the Denver Zoo Waste-to-Energy System. Additional details are Confidential Business Information of DZF. See section above titled "Confidential Business Information."

Table 11.2.3 (E) Equipment Identification [See drawing M-0]

Equipment Identification	
Equipment #1-1 (loader)	Equipment #5-1 (densification)
Equipment #1-2 (bin 1-2A)	Equipment #5-4 (conveyance)
Equipment #1-3 (shredder)	Equipment #5-2 (pellet cooling)
Equipment #1-4 (auger)	Equipment #5-3 (conveyance)
Equipment #1-5 (conveyance)	Equipment #6 (conveyance)
Equipment #1-6 (conveyance)	Equipment #7 (conveyance and storage)
Equipment #1-7 (bins A,B, C)	Equipment # 8-1,8-2,8-3 (converters/incinerator/gasifier)
Equipment #1-8 (conveyance)	Equipment # 8-5 (enclosed flare)
Equipment #1-9 (conveyance)	Equipment #9 (gas clean-up)
Equipment #2 (conveyance)	Equipment #10-2 (internal combustion engine)
Equipment #3-1 (dryer)	Equipment 11-1, 11-2 ,11-5 (heat exchangers)
Equipment #3-2 (air filtration)	Equipment 11-3, 11-4 (glycol/water tanks)

Equipment Identification	
Equipment #17 (conveyance)	Equipment 11-6 (boilers)
Equipment #15 (secondary shredder)	Equipment #14 (electrical equipment)
Equipment #18 (conveyance)	Equipment #19 (micro-turbine)
Equipment #4 (conveyance)	Equipment #8-11 (tar/particulate sampling)

Air emission control information is provided in Appendix D

(F) Water collection/storage/treatment (see drawing C-2)

Floor drains located within the Waste Management Building, specifically the main floor processing area, and floor drains located in the outdoor covered processing area and the associated liquids holding vault, all drain to the sanitary sewer, via a sand oil interceptor. This configuration was submitted and approved by Metro Wastewater of Denver (SUDP permit #200910118). It is anticipated that any waste water in the Waste Management Building will consist of wash down water from potential cleaning activities on equipment; otherwise, these drains will not be used on a regular basis.

DZF will continue to work to identify the appropriate wastewater permits to manage any industrial waste water discharges that may be developed as part of continuing operations.

(G) Support Equipment (see drawing D-0)

In order to access and maintain equipment located inside the Waste Management Building, DZF installed an overhead crane inside the Waste Management Building. The crane is a five ton Shawbox hoist and trolley bridge crane (see drawing D-0). This crane will be utilized to install the equipment inside the Waste Management System as well as maintain it during operation by having the capability to reach and pull motors/gearboxes from difficult to reach locations throughout the building.

An on-site bobcat will be utilized to move materials around as necessary. The outdoor dry storage containers will be loaded into 3 yard bins (see additional detail in Section 11.2.2(B) 5 of this EDOP) and loaded directly into the equipment #1-2 for further processing.

An on-site 10,000 lb box-car forklift will be utilized to move and load equipment that requires maintenance outside the Waste Management Building. Equipment will be moved to a central pick-up location near door garage door #1 of the Waste Management Building and loaded on a commercial truck.

(H) Anticipated recovery rate of marketable materials/energy

Energy flow as material is processed into a solid fuel, gasified, cleaned, combustion of resultant syngas with supplemental inputs of natural gas in the generator is modeled to provide an estimated 1.1 MMBtu/hour of thermal energy and 161 kWe of electrical energy generation.

Additional detail is Confidential Business Information of DZF. See section above titled "Confidential Business Information."

(I) Gasifier/Incinerator Information

The incineration (thermal conversion) of waste material processed through the Denver Zoo Waste-to-Energy System will occur in the gasification system portion of the Denver Zoo Waste-to-Energy System.

DZF has self-manufactured the gasification system portion of the Denver Zoo Waste-to-Energy System.

The gasification system was designed by DZF using the Imbert style downdraft gasification system as the foundation for design. The system itself is a controlled partial combustion system. The solid fuel is given only enough oxygen (through atmospheric air) to support the thermal conversion of the materials to produce synthesis/producer gas. The temperatures for the system are monitored to a range of 760°C to 820°C. Solid fuel entering the system will be exposed to various increasing temperatures as it travels vertically downward. The various temperature zones will be increasingly smaller as it approaches the 800 C temperature zone and is gasified (converting the carbon in the solid fuel).

The system is controlled by Equipment #8-5 (flare), which is designed to be enclosed and will destruct the resulting synthetic gas before discharge to the air. Additional detail as to the gasification process is Confidential Business Information of DZFs See section above titled "Confidential Business Information."

The operation, monitoring, maintenance, training, and startup/shutdown procedure documentation for the gasification system is required and will continue to be developed and submitted to CDPHE Air Pollution Control Division following the requirements listed in Other Solid Waste Incinerator (OSWI) subpart EEEE, specifically within the site documentation 60.2910. This documentation will be shared with the City as required within the operational guidelines that must be followed (within 6 months after initial start-up).

(J) Physical and Chemical Composition of ash or residue produced

(a) Discussion of Ash Analytical Results from Prototype Equipment. Provided in this section is a brief summary of the analytics performed by DZF on the ash byproduct produced from the operation of DZF's prototype waste-to-energy processing equipment, and the analysis of the fuel pellets made by such prototype from seasonal fuel mixture types, which included materials from external resources (i.e. waste dog food). The byproduct is described as a char/ash material left over after the gasification of the solid fuel. The analytical result information can be found in Table 11.2.3 (J2), Prototype Laboratory Testing Results Summary, below. DZF would like to stress that the ash samples specifically taken from the prototype are not representational to the scaled up version of the Denver Zoo Waste-to-Energy System, given the experimental design parameters applied to the prototype samples and the different operational parameters and fuel mixture (i.e. future fuel will not include external resources, other than

what has been approved by Parks and Recreation), between the prototype and the scaled up version of the Denver Zoo Waste-to-Energy System. Once the Denver Zoo Waste-to-Energy System is operational at the Waste Management Building, DZF will procure analytics on the physical and chemical composition of the ash byproduct produced from the operation of the full-scale system, including but not limited to: moisture density relationships, particle size distribution, volume and weight, elemental ash assessment, and such analytics will be shared with CDPHE and the City.

The chemical analysis performed on the ash byproduct generated from the prototype was conducted in 2012 by Huffman and Hazen Laboratories. In addition, between 2007 and 2014 DZF requested Huffman and Hazen Laboratories to conduct analysis on various fuel pellets developed by DZF with prototype equipment from seasonal fuel mixtures. The analysis on the pellets included Proximate, Ultimate, and Metals. The Proximate and Ultimate analyses were performed in accordance with ASTM standard D3172 and D3176, and the elemental ash analysis was performed in accordance with ASTM E1755. The procedure exposes the pellets to heat and the resulting ash byproduct is analyzed.

Further discussion of the prototype analytics is included below, organized by the year when the relevant analysis was performed.

Discussion of 2007 Data from Summary Table. Fuel materials for 2007 samples were collected over two days using statistical estimates. The material was processed to form a pellet, and submitted for analysis at two testing laboratories. The samples were referred to as Mix A (summer fuel mixture, 20% wood chip content), and Mix B (winter fuel mixture, 19% wood chip content). The composition in summer fuel mixture (Mix A) is compensated with more woodchips to supplement the change in biomass being less in the summer season.

The data shows a consistency between the two laboratories reflecting lower concentration values in Mix B compared to Mix A in core elements (C, N, H, and O). Both labs also found consistent values for sulfur. Ultimate analysis from both labs found more ash content in Mix B as a result of greater biomass content. The primary contributor was higher overall sand content in Mix B, as verified by Hazen's elemental analysis which reflected higher silica content. (Refer to table, Prototype Laboratory Testing Results Summary for details)

The elemental analysis performed on both samples is consistent for most areas besides, silica, lime, sulfur trioxide. As discussed, silica content reflects extra sand content from biomass in Mix B. Higher lime content in Mix A results from more wood used in Summer Mix A. The sulfur trioxide numbers are significantly different. Due to nearly exact sulfur numbers in ultimate analysis, the sulfur trioxide numbers in elemental analysis may be in error. After review of original reports on these samples, there is no transcription error from their reports to our data summary. However, after further review, the total content does not add to 100% and may be an associated testing error from the laboratory. (Refer to Table 11.2.3 (J2), Prototype Laboratory Testing Results Summary, below, for details).

The analysis for metals in the ash shows variability between Mix A and B, between testing laboratories and tested mixtures. This can be expected when testing for trace elements. Otherwise, metal in ash shows higher values in Mix B than Mix A from both testing labs for arsenic, chromium, lead, selenium, and silver. However, between the testing labs, there appear to be irregularities showing significant differences for barium, and lead. We observed that most values from Hazen (metal in ash analysis) are higher than Huffman. These higher values may be reflected in different sub-sampling methods by each testing laboratory. All this considered, subsampling may have contributed to outlying barium values between samples and testing labs. (Refer to Table 11.2.3 (J2), Prototype Laboratory Testing Results Summary, below, for details).

Discussion of 2012 Data from Summary Table. The second sampling round in 2012 was adjusted for further analysis, including investigating and analyzing the impacts of different plastics (switch from petroleum based plastics to a compostable plant based plastics), overall reductions in concession waste generation, and the addition of certain dry waste materials such as waste animal food and external cardboard and wood sources. The samples were collected following a run on the second prototype waste-to-energy processing equipment that included very similar material samples to 2007. The differences in the fuel samples included the addition of approximately 30% waste dog food. Ash samples were processed and collected from the bottom ash area and the throat of the prototype gasifier. Both fuel pellet and ash samples were submitted to Hazen Laboratories. The pellets were provided in two types: pellet P1 (Zoo waste- excluding elephant waste in the waste collected from herbivores due to concentration of silica from yard - including 30% waste dog food material) and pellet P2 (Zoo waste animal waste pulled specifically from elephants to determine silica effects on process)- no waste dog food material). DZF was testing the removal of elephant waste from process and the addition of waste dog food to determine extreme effects on gasifier operation. The analysis will reflect ultimate, elemental, and metals in ash analysis. Again, no ultimate analysis for ash sample.

The ash generated from the testing of the second prototype waste-to-energy processing equipment identified the presence of sand that was picked up from the waste collected in the new elephant building within the Toyota Elephant Passage ("TEP") exhibit at Denver Zoo (more detail is provided below). Ultimate analysis shows similar results between P1 and P2 values. P1 has higher nitrogen content, and conversely lower oxygen. Except as related to the introduction of sand as described above, the results collected from 2007 compared to 2012 do not show any significant differences in ultimate analysis of the ash. (Refer to Table 11.2.3 (J2), Prototype Laboratory Testing Results Summary, below, for details).

The elemental analysis results show P2 with higher silica content as a result of residual sand adhering to elephant waste. The analysis shows considerable consistency across most areas within 2012 and 2007. Lime content is lower in 2012 results because a higher portion of wood was used in 2007 fuel mixtures. The higher levels of ferric oxide in 2012 samples are likely the result of waste dog food supplementation in P1 pellets. The presence of iron is common in dog food and reflected in higher levels between P1 and P2. Sulfur trioxide is higher in P1 compared to P2. Higher sulfur content reflected in ultimate analysis between P1 and P2 supports the likely formation of more SO₃ in the process of forming ash. The controlled

use of chlorine on site and overall reductions of chlorine use at Denver Zoo has reduced the chlorine levels. The overall ash generation has dropped a little from 2007 as well, but still hovers between 25-30% by weight of material in the ultimate analysis (see Table 11.2.3 (A-3) (Proximate/Ultimate Analysis for Solid Fuel Mixture). The table below shows the estimated weights of ash to be generated from this system. (Refer to Table 11.2.3 (J2), Prototype Laboratory Testing Results Summary, below, for details).

The presence of metals in the ash remained consistent between the samples. Barium was generally consistent with both 2007 and 2012 Hazen test results. Specifically, a lower barium content in P1 samples was repeatable. Again, sample P2 has a higher sand content and likely drives the barium content higher in this sample. Cadmium and mercury are repeatable across all 2012 samples and reflects the consistency of 2007 Hazen testing. Cannot account for variability in chromium, lead, selenium and silver values as there were no trends between P1 and P2. (Refer to Table 11.2.3 (J2), Prototype Laboratory Testing Results Summary, below, for details).

Discussion of 2014 Data from Summary Table. The tests conducted in 2014 included ultimate and elemental analysis only. Fuel pellets were similar to Mix A and Mix B, but with nearly double the content of woodchips. This brought the overall woodchip content to about 40% - 41%. Again, Mix A has slightly higher woodchip content than Mix B. The results for Mix A and B are nearly the same in all categories of ultimate and elemental analysis. The slight variance in titanium oxide and ferric oxide is likely explained by increase in woodchip content for Mix A. The higher woodchip content also raises the lime value, supported by the higher lime value in Mix A compared to Mix B. Also note, the nearly doubled values for lime content comparing 2007 (~20% woodchip) to 2014 (~40% woodchip). We cannot account for the significant levels of carbon dioxide in 2014 samples compared to 2012 samples tested by Hazen. (Refer to Table 11.2.3 (J2), Prototype Laboratory Testing Results Summary, below, for details).

The overall ash generation has dropped a little from 2007 as well, but still hovers between 25-30% by weight of material in the ultimate analysis (Refer to Table 11.2.3 (J2), Prototype Laboratory Testing Results Summary, below, for details).

Table 11.2.3 (J2)

Laboratory Testing Results Summary

Name		2007 Mix A - Huffman	2007 Mix B - Huffman	2007 Mix A - Hazen	2007 Mix B - Hazen	2012 Sample #3/#6	2012 Sample #1/#2	2012 Sample #9/#10	2014 Sample Mix A (WC added)	2014 Sample Mix B (WC added)
Sample Type		pellets	pellets	pellets	pellets	ash, RZ	pellets	pellets	pellets	pellets
Year		2007	2007	2007	2007	2012	2012	2012	2014	2014
Lab		Huffman	Huffman	Hazen	Hazen	Hazen	Hazen	Hazen	Hazen	Hazen
Mix		Mix A	Mix B	Mix A	Mix B	P1	P1	P2	Mix A (WC added)	Mix B (WC added)

Ultimate Analysis	Moisture		4.27%	3.95%	21.25%	30.78%	N/A - Ash	9.46%	5.31%	1.64%	1.39%
	Carbon	C	40.27%	36.10%	38.02%	31.85%	N/A - Ash	38.31%	38.14%	11.82%	11.98%
	Hydrogen	H	5.78%	5.11%	4.71%	3.93%	N/A - Ash	4.23%	4.52%	6.34%	6.26%
	Nitrogen	N	1.33%	1.13%	1.04%	0.68%	N/A - Ash	2.26%	0.77%	0.67%	0.62%
	Sulfur	S	0.32%	0.32%	0.22%	0.24%	N/A - Ash	0.19%	0.09%	0.05%	0.08%
	Ash		23.53%	32.27%	16.34%	21.85%	N/A - Ash	25.86%	25.75%	3.78%	3.88%
	Oxygen	O	33.27%	31.74%	18.42%	10.67%	N/A - Ash	19.69%	25.42%	37.29%	37.76%
Elemental Ash Analysis	Silica	SiO2	DNT	DNT	51.49%	56.07%	55.85%	58.11%	70.49%	27.57%	29.16%
	Alumina	AL2O3	DNT	DNT	8.28%	8.80%	10.38%	10.53%	9.14%	6.58%	7.13%
	Titanium Oxide	TiO2	DNT	DNT	0.54%	0.50%	0.07%	0.35%	0.15%	0.91%	0.70%
	Ferric Oxide	Fe2O3	DNT	DNT	3.78%	3.48%	12.75%	8.86%	5.51%	11.23%	10.10%
	Lime	CaO	DNT	DNT	14.30%	11.00%	5.33%	4.89%	4.10%	26.50%	25.80%
	Magnesia	MgO	DNT	DNT	2.24%	1.96%	1.19%	1.26%	0.75%	2.66%	2.62%
	Sodium Oxide	Na2O	DNT	DNT	3.11%	4.59%	2.99%	3.42%	2.67%	4.08%	3.82%
	Potassium Oxide	K2O	DNT	DNT	6.31%	5.74%	5.46%	6.01%	5.04%	9.12%	9.22%
	Phosphorus Pentoxide	P2O5	DNT	DNT	4.72%	2.84%	2.30%	2.61%	1.21%	3.43%	3.45%
	Sulfur Trioxide	SO3	DNT	DNT	3.17%	0.21%	0.62%	0.98%	0.61%	1.13%	1.25%
	Chlorine	CL	DNT	DNT	2.05%	3.13%	0.96%	1.86%	0.57%	1.97%	1.93%
	Carbon Dioxide	CO2	DNT	DNT	0.45%	0.54%	0.07%	0.12%	0.08%	4.63%	8.91%
Metals in Ash			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg		
	Arsenic	As	1.5	1.8	6.00	4.37	4.8	3.49	3.85		
	Barium	Ba	112	21	1260.00	1130.00	716	734	952		
	Cadmium	Cd	0.8	0.5	2.00	2.00	7.00	6.00	6.00		
	Chromium	Cr	19	23	50.00	70.00	472	117	358		
	Lead	Pb	15	21	64.00	120.00	16.0	48.0	55.0		
	Mercury	Hg	0.03	0.03	0.05	0.04	0.01	0.01	0.01		
	Selenium	Se	2.3	3.6	2.00	2.00	0.13	0.41	0.17		
Silver	Ag	0.3	0.6	2.00	4.00	2.00	6.00	4.00			

Mix A (summer mix)

Mix B (winter mix)

P1: Zoo waste with 30% Purina

P2: Zoo waste from Elephants (included residual sand)

DNT (Did Not Test)

WC (woodchips)

(b) Estimated Weights of Ash from Denver Zoo Waste-to-Energy System. Table 11.2.3 (J1) below shows the estimated weights of ash to be generated from the Denver Zoo Waste-to-Energy System.

Table 11.2.3 (J1) Estimated Ash Volumes from ultimate analysis

Sample Description	Daily Estimated Ash Volume	Daily Estimated Ash Weight	Particle Size
Summer Material Mix (no added animal food waste)	75 cuft	2500 lbs	Not available at this time
Winter Material Mix (no added animal food waste)	85 cuft	2800 lbs	Not available at this time

(c) Additional Analytics. As stated above, once the Denver Zoo Waste-to-Energy System is operational at the Waste Management Building, DZF will procure analytics on the physical and chemical composition of the ash byproduct produced from the operation of the full-scale system, including moisture density relationships, particle size distribution, volume and weight, and such analytics will be shared with CDPHE and the City. See also Section 11.2.3 (K) below.

(d) Additional Information-Metals in Ash and Plan for Ash Exhibiting Hazardous Characteristics (if applicable). Using the sampling results for metals in the ash and comparing it to the Table 1 of 40 CFR 261.24 Maximum Concentration of Contaminants for the Toxicity Characteristic, ash generated from equipment #8-1, 8-2 and 8-3 will be tested using the Toxicity Characteristic Leaching Procedure, test Method 1311 in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," EPA Publication SW-846, to confirm proper disposal methods of this byproduct. DZF will manage our waste streams in accordance with federal, state and local regulations, including but not limited to requirements identified in Colorado Hazardous Waste Regulations 6 CCR 1007-3. . If ash is determined to exhibit hazardous characteristics, then DZF will meet all of the notification requirements of section 3010 of the Resource and Recovery Act (RCRA) and all applicable requirements under parts 262 through 265, 268 and 270 of the RCRA regulations. See also Section 11.2.3 (K) below. DZF also recognizes that if the ash is characterized as hazardous, such characterization will result in a change of DZF's generator status from CESQG to LQG. DZF is developing a procedure for addressing this change, if applicable, and how DZF will address the associated requirements for LQG. Such procedure will be shared with the City and CDPHE, once available.

(K) Disposal, Storage, and Processing of Ash, scrubber residue, volume, weight (see drawing M-1)

1. Disposal, Storage and Processing of Ash

As described in 11.2.2 (B)(2)(c)(i) of this EDOP, an 1,801 cubic foot, subgrade, waterproof, concrete ash pit resides within the Waste Management Building (below equipment #8-1, 8-2, and 8-3), dedicated to collecting any ash generated during the waste-to-energy conversion process. There is no floor drain in the bottom of this ash pit. This indoor "ash vault" will be utilized to only collect and temporarily store (before disposal) the ash byproduct.

Although laboratory testing has been performed using the prototype gasifiers, the scaling and design changes made for the larger gasifier may affect the analysis results. DZF will work with CDPHE and communicate with the City and County of Denver (the "City") on results of further analysis of ash generated by the full-scale Denver Zoo Waste-to-Energy System and other byproducts. DZF has the financial and regulatory responsibility for all waste (hazardous, non-hazardous, sampling, analysis, disposal) of the additional waste generated by the waste to energy system. DZF will manage (includes: assessment, sampling costs, disposal contracting, and all costs associated with disposal) our waste streams in accordance with federal, state and local regulations, including but not limited to requirements identified in Colorado Hazardous Waste Regulations 6 CCR 1007-3 and utilization of CDPHE's Beneficial Use Determination (BUD) to characterize the ash and any other waste components generated in the process.

The BUD regulations applicable to beneficial use of solid wastes are set forth in Section 8.6.1(C) of the Colorado Solid Waste Regulations and require that a Beneficial Use Determination (BUD) be made on the specific material prior to its unrestricted use. DZF will refer to Section 8.6.1 and 40 CFR 261, for analytical testing requirements, guidelines, reporting and permitting requirements. In addition, prior to any beneficial use of ash on City property (i.e. Denver Zoo grounds), DZF will submit the BUD and proposed plan for use to the City for approval. DZF will share the associated analytical data for each waste type including process water and ash with the City to ensure property waste characterization and proper disposal.

In regards to ash disposal, DZF has identified a local company to mechanically remove ash approximately once every 30 days from the ash vault located inside the Waste Management Building and dispose of the ash byproduct as determined following proper waste characterization (as described above). The maximum quantity of ash that can be stored in the ash vault at any one time is approximately 60,000 lbs (refer to Table 11.2.3 (C2) (Material Storage Schedule - Equipment) according to approximate density calculations for the ash. If the ash must be landfilled, the ash will be stored in lined/bagged vacuum boxes to mitigate weather concerns that could spread ash at the landfill. These vacuum boxes are Department of Transportation approved. *[If ash is characterized as hazardous, DZF will ensure that the vendor will, before transporting hazardous waste or offering hazardous waste for transportation off-site, package the waste in accordance with the applicable Department of Transportation regulations on packaging under 49 CFR parts 173, 178, and 179.]*

The vacuum system utilizes cyclone and filters to ensure that the exhaust meets the PPM requirements associated with removal. As stated above, DZF will work with CDPHE and the City as to waste

characterization of the ash and any other waste components generated in the process. Once consistent data on the ash has been collected, DZF will re-analyze the ash if there is any change in the process or solid fuel mixture and at such other times as may be determined by DZF's Safety and Sustainability Department.

The safety and access procedures for the ash vault are still being developed with outside contractor input. We will provide updates to this EDOP and submit the revisions to CDPHE and the City upon completion of the final procedures. The applicability of air permit requirements associated with fugitive emissions associated with the removal of ash are also being assessed. If an additional air permit is determined to be required, DZF will comply with the additional permit procedures set forth in the introductory paragraph of this Section 11.2.1 (F) and will submit to CDPHE and the City any necessary amendments to the EDOP.

Removal of the ash by the contracted company will require monitoring of the vent gas from the ash vault to be below 10 ppm for combustible gasses prior to entering and vacuum extraction. Procedures will be developed with contractor as process moves forward to assure safety and handling requirements are met. All updated documentation will be shared with CDPHE and the City when developed.

In the case of considerable changes to fuel, additional ash testing will be performed to determine any variance to normal ash chemical composition. Appropriate action(s) will be implemented to address any variance above allowable limits. Actions may include evacuation of the ash vault before allowable limits are reached, or removal of ash vault as a result of superseding allowable limits. In the latter case, prescribed protocols will be in place with approved vendors to handle the safe and effective removal of hazardous ash waste.

DZF would like to emphasize that an objective of developing the Denver Zoo Waste-to-Energy system was to support Denver Zoo's efforts to be a zero waste facility by 2025. This system is being designed and every consideration is being made to ensure that the byproducts produced from this process do not impact this objective. We are committed to the development of a fuel mixture that will support beneficial use of ash as our largest volume byproduct and will continue to test and modify processes to support our program objectives.

In regards to sampling procedures, provided below is a proposed approach and methodology, specifically for the ash byproduct. All sampling protocols will be managed in accordance with federal and state requirements.

Ash Sampling Procedure (general description):

Described below is the general description of the ash sampling procedures for the Denver Zoo Waste-to-Energy System. Any updates to these procedures, including records, will be shared with CDPHE and the City as an amendment to the EDOP, when developed.

Sample Documentation. DZF will maintain detailed instructions for sample collection and management of ash at the Waste Management Building. Any associated notebooks, lab reports and files will also be maintained at the Waste Management Building and reviewed for accuracy during internal site compliance audits conducted in accordance with DZF's Sustainable Management System (SMS). In addition, DZF will maintain records associated with training of responsible parties on sampling procedures. All records will be maintained in accordance with DZF's SMS procedures. Records will be maintained for 3 years.

Sampling Frequency. Ash vault evacuation is planned for every 30-days of operation. Ash sampling frequency will occur every two weeks within the first six months of operation, in order for DZF to build a database of results to demonstrate consistent concentrations as part of our waste determination. After the first six months, or after a point that the Denver Zoo Waste-to-Energy System is deemed fully operational, DZF will reduce sampling frequency to once every month, until three consecutive sampling rounds with consistent results have been obtained and DZF is satisfied with the level of consistency in the fuel mixture. After three consecutive results and confirmation of consistent fuel mixture, DZF will cease regular monthly sampling. Monthly sampling will be reinstated if there is any change in the process or solid fuel mixture and at such other times as may be determined by DZF's Safety and Sustainability Department; any reinstatement of monthly sampling will stay in effect until three consecutive sampling rounds with consistent results have been obtained (taking into consideration the level of consistency being obtained in the fuel mixture) and DZF is satisfied with the level of consistency in the fuel mixture.

Sampling will be conducted to allow for sufficient lead time between testing and the logistics associated with coordinating ash vault evacuation by third-party vendors. Upon determination of the chemical composition of an existing ash pile in the ash vault, appropriate action will be taken to evacuate such ash pile.

Sampling Methodology. DZF will collect samples of the ash through a stratified random sampling method. This is accomplished by collecting multiple subsamples from a sample population both through the depth of the ash vault and from around its lateral plane. The subsamples are mixed together and represent a "most uniform" composition of the sample population itself. Sampling probes will be utilized to allow for accurate depth and volume extracted; and will introduce minimal disturbance of ash pile. In addition, a balance will be used to determine accurate weight of a sample.

By performing the stratified random sampling method, DZF will create a representative sample population from at least 12 sub-samples. The ash pile will be divided into four quadrants laterally. At least 3 samples must be taken from each quadrant. Quadrant sub-samples must be taken from at least three of four different depths: shallow (6"), medium (18"), deep (30"), and max (40"). No two sub-samples can be taken from the same extraction point and only one sub-sample per extraction.

All sub-samples will be delivered to a clean mortar and pestle mixed gently so not to create dust. Subsamples will be mixed until the granularity reaches a uniform consistency. Using a micro spatula, deliver 20.0 grams of randomized and mixed sample a sample container. Secure the container cap, and label the outside of the container with sample code and transcribe appropriate information into notebook.

The DZF sampling technicians will make all efforts to protect themselves from direct contact or interaction with the samples. Technicians will make all effort to practice Quality Assurance and keep contaminant free: sampling probes, mixing devices (motor and pestle), sub-samples, samples, and sample vials.

Quality Assurance. In the event a sub-sample is contaminated (i.e. probe fragment, external chemical compound, contact with floor, paint chip, etc.), the sub-sample will be completely discarded into appropriate containers for ash discard. If a sample (the collection of sub-samples) is contaminated (i.e. probe fragment, external chemical compound, contact with floor, paint chip, etc.), the entire sample will be completely discarded into appropriate containers for ash discard. If a sampling probe is contaminated (i.e. dirt, external chemical compound, contact with floor, paint chip, etc.), it may not be used for any sampling until it is cleaned accordingly.

Personal Protective Equipment (PPE): Includes any device, material, or barrier that limits, or restricts, the exposure (physical, or time duration) of skin, airways, eyes, ears, mouth, mucus membranes, etc., to potential hazards (physical, chemical, optical, irritant, etc.). Examples of general PPE include: gloves, foot and eye protection, protective hearing devices (earplugs, muffs) hard hats, respirators and full body suits. Refer to OSHA 3151-12R, 2003.

2. Tar and Scrubbing Liquid Recycling and Removal

DZF will continue to work to identify the management of any scrubber residues (tars/liquids/acids), water, etc., that may be developed as part of the operation, including operational design changes, of the Denver Zoo Waste-to-Energy System. As information becomes available, DZF will manage such scrubber residues or other outputs in accordance with federal, state and local regulations, including but not limited to requirements identified in Colorado Hazardous Waste Regulations 6 CCR 1007-3.

DZF's initial assessment is that tar is a major obstacle in gasifier technologies. Even in downdraft gasifier designs, the output of tar is below 1%. Despite this low throughput, these levels lead to mechanical and operational issues, such as pipe clogging and mechanical fouling. Many strategies have been investigated to reduce tar content. Surjosatyo conducted a review of gasifier applications and the implementation of technologies and discusses process pathways to reduce overall tar content².

² A. Surjosatyo, et al., A Review on Gasifier Modification for Tar Reduction in Biomass Gasification, Journal Mekanikal, 31 (2010) 62 - 77.

Research groups have shown success in recycling both tar and respective scrubbing water through the gasifier without impinging on mechanical operation^{3,4,5}. Recycling more than 70% of tar provided best results, while experiments recycling tar showed considerable success reducing tar content by 75 - 97%⁶. The reintroduction of recycled tar is effectively demonstrated by the DeLacotte tar recycling gasifier that mixes tar and air into the pyrolysis zone of the gasifier⁷. Tars can be recycled within the gasifier system directly (direct injection) or indirectly (via fuel mixing) contributing to overall efficiency enhancement rather than impose a waste problem⁷. DZF plans to capture tars using wet scrubbing techniques that will reintroduce the output tar into the gasifier through integration with solid fuel (wood and straw). DZF estimates that approximately 64 lb/hr or tars and scrubbing liquid, each comprising the total rate at 50% by weight.

There are two areas that the liquid could be reintroduced that could benefit and provide an effective means of disposal:

1. A secondary feed drip system to the gasifier for ease of handling and control. The liquid would be pumped up to the gasifier and delivered with compressed air as a mist into the reaction/gasification zone.
2. Addition to material prior to pelletizing. Liquid/tars could assist as a binder for the pellets and also increase the energy content of the fuel.

Subject to further calculations, DZF plans to recycle 95% of the scrubbed tar resulting in capturing tar at a rate of 1 drum (55-gal) every three weeks of operation. Tar recycling is estimated at 6% of fuel by weight and ~8% when supplemented with solid material (straw/wood). Ratio of tar to supplemental material will be about 6:1 by volume.

Once the Denver Zoo Waste-to-Energy System is operational at the Waste Management Building, DZF will be testing, in accordance with Federal, state and local regulations, the scrubbing liquid and any other liquid waste to determine if any such liquids are subject to regulation and permitting under applicable Federal, state or local wastewater regulations. Existing calculations indicate scrubbing liquid will incur volumetric losses due to recycling and will require removal of approximately 1 drum (55-gal)

³ P.C.A. Bergman, The novel "OLGA" technology for complete tar removal, Pyrolysis and Gasification of Biomass and Waste, Expert Meeting, 2002.

⁴ Y. Neubauer, Strategies for Tar Reduction in Fuel-Gases and Synthesis-Gases from Biomass Gasification, Journal of Sustainable Energy & Environment Special Issue (2011) 67-71.

⁵ A. van der Drift, et al., Milena Gasification Technology for High Efficient SNG Production from Biomass, Published at 14th European Biomass Conference & Exhibition, 2005.

⁶ H. Susanto and A. A. C. M. Beenackers, A moving-bed gasifier with internal recycle of pyrolysis gas, Fuel, 75, 11 (1996) 1339-1347.

⁷ A. Kaupp and J.R. Gross, State of The Art for Small (2-50 kW) Gas Producer Engine System, Final Report to USDA, Forest Service, Contract No 53 – 39R-0-141, 1981.

per 2 weeks of operation. DZF will request assistance and approval from the City and County of Denver's Department of Environmental Health (DEH), Metro Wastewater and CDPHE for testing and proper disposal/handling of liquid waste generated by the Denver Zoo Waste-to-Energy System.

This Section 11.2.3 (K) has been prepared by DZF based upon the information and analytics available to DZF as of the time of its application for Certificate of Designation. As DZF obtains updated information, analysis, and assessments relevant to the disposal, storage and processing of ash, scrubber residues and any liquid wastes, DZF will share such information, analysis, and assessments with the City, Metro Wastewater and CDPHE and will also prepare and submit any necessary amendments to the EDOP.

(L) Plan for disposal or processing of waste in shutdown scenario

An upset condition for the Denver Zoo Waste-to-Energy System is defined as a situation that would preclude the facility from receiving or processing incoming waste. In these situations, there will be a known amount of time to adjust to the scenario. In that time, waste will be diverted into a compactor or into a roll-off that is maintained adjacent to the Waste Management Building. DZF will contract with a hauling service to retrieve the waste and deliver to a pre-approved landfill. This roll-off can serve as the sole daily waste container if necessary. Currently, the entirety of zoo waste is handled by a roll-off system like this, so this practice should be adequate in the future. Any waste identified in the category of recycling will continue to be managed through DZF's onsite recycling roll-off, which is housed in the Gate 7 Operations parking area at Denver Zoo.

This procedure returns to previous operation minus the use of separated waste for composting. This would mean that previously composted waste would be going to landfill for the duration of the shutdown. For additional information the process for removal of materials from equipment, refer to Section 11.2.4 C.

(M) Utilities to be installed (refer to drawings E-1 and P-0 and P-1)

(N) Plans and designs for operating and maintaining the proposed facility to prevent fires, explosions, and the emissions of toxic gases and/or other emergencies

The building was constructed to meet the F-1 (Factory Industrial) moderate hazard occupancy classification code. It is a one story building with a mezzanine level control room, type VB construction, automatic sprinkler system, and a fire resistant assembly with a one hour construction wall (UL U905) at exterior wall facing the Denver Zoo's Filtration/Hay Storage Building. There are two main exits out of the Waste Management Building.

1. Fire safety monitoring

The Waste Management Building is tied to the main ventilation system of the Toyota Elephant Passage (TEP) exhibit. Air is monitored throughout the exhibit's buildings for quality, gases, particle capture and dust collection. The waste-to-energy processing (gasification) equipment (Equipment # 8-1, 8-2, 8-3) are maintained separately as NFPA Class 1, Division 2 as determined

by our licensed electrical and mechanical engineering consultants. An 8' steel wall will provide a sealed barrier to separate any electronic equipment that does not meet the safety specifications (explosion proof). Above each piece in equipment # 8-1, 8-2, 8-3 there will be large hooded ventilation fans that will exhaust approximately 10,000-12,000 CFM of air if any CO or H₂ gas is detected. This is performed more for safety purposes related to the quantities of carbon monoxide generated and not the explosion risk. An assessment of the syngas generated showed that it is not considered a combustible when mixed with 13 percent or less air by volume, according to the International Fire Code 2006, Chapter 35. This current design will be provided by DZF's licensed engineering consultant(s) and will be installed a licensed contractor. The detection of combustible gases (hydrogen, carbon monoxide, and methane) are being tracked by a dual sensor gas detector (GDD services Kele specialty gas sensors) with a resolution of up to 1ppm CO, .5% H₂ and CH₄.

Exhaust from the ventilation fans within the Waste Management Building does not currently require permitting for emissions. Exhaust from the ventilation fans is secondary handling of emissions associated with specific pieces of equipment. In August 2013, DZF submitted to the Air Pollution Control Division of CDPHE calculations for fugitive emissions associated with specific pieces of the equipment associated with the Denver Zoo Waste-to-Management System. The fugitive emissions were below the reporting threshold for an Air Pollutant Emission Notice (APEN) submittal so no further action is required to be taken by DZF as to APEN submittals or permitting at this time. DZF will monitor fugitive emissions on an ongoing basis using the EPA Method 22 procedures (the official Method 22 is available at www.epa.gov/ttn/emc/promgate/m-22.pdf). CDPHE has confirmed DZF's use of EPA Method 22 for ongoing monitoring and testing of fugitive emissions. If, at a future time, fugitive emissions exceed the reporting threshold for an Air Pollutant Emission Notice (APEN) submittal, then DZF will submit a revised APEN, together with any related documentation, to CDPHE and comply with all applicable reporting and permitting requirements. DZF will keep the City informed of its monitoring activities with respect to fugitive emissions and any future reporting and/or permitting requirements. As to any additional permits required to be obtained, DZF will comply with the permit procedures set forth in the introductory paragraph of Section 11.2.1 (F).

The gas detectors used to detect and track combustible gases (hydrogen, carbon monoxide, and methane) will be maintained and calibrated according to supplier manual and documentation. Currently, this includes 6 month inspection requirements and replacement (typical) are as follows: CO – 6 year typical lifespan, H₂ – 2 year lifespan, and CH₄ – 2 year lifespan. Manufacturer supplies calibration kits for reinstallation, typical calibration only occurs when unit sensors reach typical lifespans.

The alarm system is built into the gas sensor and puts out an 85 dB alarm noise. The sensor will be set for two alarm scenarios: 1) alarm for detection of gas followed by exhaust fans operating at full speed. 2) Alarm detection safety for CO – if sensors read CO values 50ppm or greater and

alarm continues to operate for specified duration (TBD), then secondary alarm in building will be triggered for evacuation. System process may go into shutdown mode but this will be determined by explosivity risk associated with continued work performed under the hazard assessment.

Currently, under the direction of the Denver Fire Department and DZF's licensed engineer consultants, DZF has sent material samples to be tested for storage using ASTM E84/UL 723 as well as evaluated under NFPA 664. Testing was performed and the material determination is still being evaluated. The analytical lab performed a combustibility test to be performed (OSHA SLTC Go/No Go). It was positive for moisture contents lower than anticipated from DZF's process (i.e. under 25% MC by weight). Using these values, dust explosibility (ASTM E1226) was performed to determine the K_{st} and P_{max} characteristics of the material. In addition to this a combustibility test, Minimum Ignition Energy (MIE) (ASTM E2019-99) and minimum auto ignition temp (MAIT) (ASTM E2021) were performed. The processed material located above Equipment #5-1 Pelletizer and delivered by Equipment #4 was determined to require additional testing and analysis based on potential hazards. This equipment handles pulverized material (.5" - .25" minus) as stated in the material storage schedule (Table 11.2.3 (C2)). DZF is currently working with its engineering consultants to finalize a report responding to the identified potential hazards. The findings of such report will be shared with the City and CDPHE once the report is completed. All other data has been collected and DZF is currently working with its engineering consultants to identify the best means to manage and maintain operational safety related to material handling. The plans, policies and procedures developed by DZF for management and maintenance of operational safety related to material handling, including ongoing monitoring, will be shared with the City and CDPHE as requested.

2. Mechanical fire suppression and prevention (see drawing P-0)

The Waste Management Building has a sprinkler system which will provide the final barrier against fire suppression within the building. The system was installed and permitted through the City and County of Denver Building Department and meets all IBC 2007 requirements. Denver Zoo participates in annual Denver Fire Department inspection on this system.

All electrical cabinets will be under a positive pressure to meet or exceed the requirements in NFPA 496. In addition, for safety and protection of the facility all maintenance staff will be required to wear a gas alert detector when working inside the facility.

Additional safety measures are employed in the syngas line leaving Equipment # 8-1, 8-2, 8-3, prior to Equipment # 8-5 there will be flame arresters installed to eliminate the possibility of flame propagation into Equipment # 8-1, 8-2, 8-3 and Equipment #10-1. On Equipment # 8-1, 8-2, 8-3 itself a pressure relief valve engineered by Leser (type 526) will be utilized as a mechanical means of alleviating significant pressure build-up in the reactor that could be caused by a

plugged line and/or another upset condition (as defined in section 11.2.4(C) of this EDOP) such as valve failure.

For increased safety and shutdown purposes, the use of pure nitrogen as an energy/heat carrier will be used inside Equipment # 8-1, 8-2, 8-3 to carry the energy contained within it during operation out and improving the shutdown time of Equipment # 8-1, 8-2, 8-3. A nitrogen generator will be installed as part of Equipment # 8-1, 8-2, 8-3 (labeled NT-1 in Drawing P-1) and provide up to 8.8 scfm @57 psig of 98% pure nitrogen to safely bring the system down in an upset condition (as defined in section 11.2.4(C) of this EDOP) .

3. Housekeeping practices

The Waste Management Building will be cleaned and maintained on a regular schedule. Internal DZF staff responsible for management of the Waste to Energy system will perform or coordinate and oversee housekeeping activities. Housekeeping activities will focus on clean up of particles or dust within the building in order to help reduce the risk of any potential fire hazard. These housekeeping activities will likely coincide with planned maintenance days. Records of housekeeping activities will be maintained by DZF's Facilities Group staff.

(O) Closure Plan for decommissioning of facility (Appendix F)

In the event that DZF is no longer able to manage the Denver Zoo Waste-to-Energy System, the following will likely need to occur.

- Third party contracting service - remove equipment associated with the system to a designated off site location.
- Third party environmental services contractor - remove all raw materials housed within the system and dispose of at designated location. Coordination on the removal of materials will be a component of disassembly of the equipment and actions to remove the assets off the property.
- Third party environmental services contractor for the assessment and any necessary remediation - return the building to its original condition.

To perform this work, DZF has established financial assurance sufficient to ensure payment of such costs incurred from the activities listed above. The financial assurance is provided in Appendix F and meets the requirements as outlined in Colorado's Solid Waste Sites and Facilities Regulations 6 CCR 1007-2, Part 1, section 1.8 Financial Assurance Criteria.

DZF will:

1. Notify CDPHE when required cost estimates have been placed in an approved funding mechanism as defined in section 1.8.
2. Annually adjust such cost estimate to account for inflation or deflation by using the implicit price deflator for the gross domestic product or its successor as published by the U.S. Department of Commerce.

3. Replace original cost estimates with new cost estimates every five (5) years unless otherwise required by CDPHE, or if new information/changes to the operation impact the closure cost estimate. A request to modify the closure plan will be submitted to CDPHE (copied to City), and the closure cost estimate will be revised no later than 30 days after DZF has received CDPHE and City approval.
4. Increase or decrease the cost estimate as long as justification is presented and accepted to local jurisdiction and CDPHE. Records shall be maintained of any request.
5. Provide financial assurance coverage continuously until a release is granted by CDPHE.
6. Maintain a copy of the latest closure cost estimate and, when this estimate has been adjusted, maintain the latest adjusted closure cost estimate.

11.2.4 Facility Operating Plan

(A) General Narrative of Operating Plan

General Information

The operations associated with how DZF consolidates, collects and transports waste within the 80 acre Denver Zoo campus will not change from how waste materials are currently being collected. The only process that will change is that acceptable waste materials will now remain on site and be processed into a consistent solid fuel pellet to be delivered to the Denver Zoo Waste-to-Energy System. Similar to other recycling programs throughout City and County of Denver, DZF will educate its employees, volunteers and contractors, as well as Denver Zoo guests, as to DZF's new waste sorting protocols at Denver Zoo as such persons look to dispose of any waste being generated from site activities. In addition, DZF is developing a site wide purchasing program that will specifically screen out materials that are not deemed compatible at end of use with the Denver Zoo Waste-to-Energy System. The estimated expected life of the facility is overall 20 years, although some components may have shorter time frames.

The schedule, operational procedures, processes and parameters, and hiring/training plan(s), for the start-up phase of the Denver Zoo Waste-to-Energy System are still being developed. DZF acknowledges that the system may not be operating at peak efficiency during start up and shut down and that appropriate operational procedures and contingency plans will be developed to ensure upsets during those timeframes are minimized. As stated in Section 11.2.3(I), the operation, monitoring, maintenance, training, and startup/shutdown procedure documentation for the gasification system is required and will continue to be developed and submitted to CDPHE Air Pollution Control Division following the requirements listed in Other Solid Waste Incinerator (OSWI) subpart EEEE, specifically within the site documentation 60.2910. This documentation will be shared with the City for review and approval. City review and approval of the documentation needs to occur within a timely manner and consider the permitting deadlines DZF is required to meet in our operating permit. The start-up description and schedule for the Denver Zoo Waste-to-Management System will be maintained as Appendix L.

More details regarding the operation of the Denver Zoo Waste-to-Energy System is provided in the sections below.

Operations Schedule

DZF anticipates operating the solid fuel processing and development portion of the Denver Zoo Waste-to-Energy System approximately 6 days a week and will receive waste during normal operating hours of Denver Zoo. Waste will be delivered to the Waste Management Building from 7:00 a.m. to 2:00 p.m. each day by DZF's grounds personnel (which currently include personnel employed by DZF, as well as certain City employees assigned to Denver Zoo that are managed and supervised by DZF in accordance with the cooperative agreement between DZF and the City). Delivery times usually occur in the morning, with increased afternoon drop off during the summer months.

1. Initial Material Processing and Mixing:

All raw waste material arrives at the front the Waste Management Building, which is the outdoor covered area where it is placed into a 3 yard storage bin. Once in the 3 yard bin data is collected electronically to record material constituents, weights, and times. The material is then introduced to the system in these 3 yard batches where it is processed by shredding and sorting into the appropriate storage bin. These operations occur during Denver Zoo operational hours between 6:00 a.m. and 3:30 p.m. shifting an hour forward to 7:00 a.m. and 4:00 p.m. in the winter months. DZF has the capability to store upwards of 20,000 lbs of material in the 3 yard storage bins before further processing in the next step.

2. Conversion of Shredded/Mixed Material into Solid Fuel

Once the storage bins have collected an entire day's worth of material the proper mixture is calculated and fed into the dryer. The shredded, mixed material is fed by weight, mixing it onto a conveyor that feeds the mechanical dryer. The dryer will be operating approximately 14 hours/day processing the material to the proper moisture content for further downstream processing. The exhaust from the dryers is mechanically pulled through an air filtration system which includes carbon filtration. Any moisture in the exhaust that may condense out in the filter system will be collected and diverted into the building sanitary drains. DZF has estimated that steam exhaust from the drying process will be approximately 280 lbs/hour of steam and air from equipment #3-1. Initial tests have shown that less than 5% of the moisture condenses in the filter forming a liquid at an estimated rate of 2 gallons/hour. This liquid will contain very little suspended solids (TSS). DZF will determine a feasible method to conduct one sampling event to perform a waste determination on the liquid. All liquid generated is fed through the sand/oil interceptor discussed in Section 11.2.2 (B)(2) of the EDOP. The material from the dryer is fed into a large hopper above the densification portion of the process. This equipment will only operate approximately 4-6 hours/day (typically between 4:00 and 10:00 p.m.) or until the material in the feed-bin above the densifier reaches its minimum requirement.

3. Processing and storage of densified material

Once the material has been densified it runs into a cooling system to harden the “pellets.” This uses a blower system to cool the pellets. The air goes through a cyclone to eliminate particulates before being exhausted into the enclosed hopper above the densifier. The exhaust from the hopper will be mechanically exhausted through an air filtration system with carbon filtration. All the cooled pellets are then delivered to a hopper that will eventually feed the gasifiers. The hopper can hold approximately 1-2 days worth of pellets for the gasifiers to operate.

4. Gasification and Energy Generation.

The gasifier(s) are designed to operate 6 days a week, leaving one day for shutdown and maintenance of it, the gas clean-up system, and the generator. The order will be Generator, followed by gas clean-up, and then the gasifier as the time it will take to cool down will be on the order of 6-8 hours even with all of the solid fuel removed. Initially, the operation schedule will be lower to test and ensure systems are operating as they should. The gasifier is designed to be fed at a maximum throughput of 430 lb/hr (either to one or multiple). The air delivery system will be provide somewhere between 850-950 lb/hr of air at all times when processing 430 lb/hr for the gasifier to convert the fuel into a combustible syngas

5. Maintenance of Processing Equipment Filters.

The process currently contains two air filter/control locations (equipment #3-1 and #5-2 – reference M-1 and M-0) which contain barrier and activated carbon (in box type enclosures) filters. DZF has worked with filtration companies (DZF currently uses Air Force Filter to handle existing activated carbon filters and will likely use them to handle/dispose of carbon as determined) and engineering consultants to size this equipment and to order appropriate activated carbon for use in these control devices. It is believed that the activated carbon use in these areas (small removal of VOCs and odor) will not cause the carbon to be hazardous and require additional handling procedures according to equipment manufacturers and the filtration companies. To determine this is the case, DZF will sample the carbon after the first replacement occurs and report this information to the CDPHE and City. The resulting data and discussions will determine additional handling procedures as required.

Maintenance

Scheduled maintenance of equipment components of the Denver Zoo Waste-to-Energy System will be performed and tracked based upon the manufacturer requirements. All components that require maintenance will be scheduled in a calendar for the Waste Management Building operations. Because much of the equipment has to run continuously, the maintenance schedule is set to be performed at pre-determined times, all related to when the gasifier is scheduled to shut down for maintenance. This is currently scheduled to occur once a week (but adjustable dependent upon the Denver Zoo schedule for free days and other major events). If the gasifier operation can be extended past a week, the

equipment is designed to allow for durations of scheduled down-time during normal business hours to perform required maintenance.

Maintenance and housekeeping efforts will be coordinated so that housekeeping generally occurs at the same time as maintenance whereby specific equipment will be nearly empty in preparation for a shutdown. Some equipment, such as equipment #3-1 (dryer), conveyors #4, #5,3 (and other matching conveyors), as well as the gasifier (#8-1), gas clean-up (#9), and even the generator (#10-1) are designed/engineered in-house and the lifespan of these pieces of equipment will be determined in early phases of testing their operation. In general, the originally installed gasifier (#8-1) will have a lifespan of approximately 100 hours before it will need to be assessed. The original manufacture and assembly of the gasifier is based upon professional knowledge and data collected from previously operating gasifiers.

To retain lower maintenance costs, DZF has invested in an auto grease feeder for equipment components that require large quantities of lubrication. The unit will initially feed just equipment #3-1 and equipment #5-1, and is built to be expanded as needed. This will eliminate the need for more than weekly maintenance for equipment that once required daily maintenance.

To track the maintenance of equipment DZF has both digital and print versions of equipment in binders. These binders and digital logs will be used to ensure that maintenance protocol is followed. Before the Denver Zoo Waste-to-Energy System is fully operational a schedule and maintenance check list will be created to accurately plan for scheduled maintenance. This will be performed by an operator and logged with a tablet computer where the maintenance is taking place. The tablet computer will work well in storing and tracking unscheduled maintenance, allowing the maintenance tech to take a snapshot of the issue, log the time and date, and then record what was performed to alleviate the task. The options for this include video, notes, photos, etc. If a component needs to be replaced, DZF has already identified all supplier and vendor information for components and ordering parts can take place quickly. Once the part is replaced a time and date stamp will note this for record keeping.

DZF is committed to improving maintenance of the equipment components of the Denver Zoo Waste-to-Energy System as well as other equipment throughout Denver Zoo. If the current software/system designed for the Denver Zoo Waste-to-Energy System works to DZF's satisfaction, DZF will roll out such software/system more broadly within Denver Zoo.

(B) Provisions for alternative waste handling or disposal (see section 11.2.3 L)

As discussed in 11.2.3L, DZF will maintain a landfill compactor and oversized roll off on-site adjacent to the Waste Management Building for use to ship materials to landfill in the event of a shutdown or other upset condition (as defined in section 11.2.4(C) of this EDOP) .

Any waste material that requires special onsite management and/or disposal in accordance with Federal or State universal and hazardous waste regulations will be managed according to the specific regulations. For DZF these include, but are not limited to: waste paint solvents, universal wastes (e.g.

batteries, aerosol cans, CFLs, fluorescent light bulbs, mercury containing devices), ballasts, used oil, spent solvent rags, pesticide or herbicide waste, waste or expired chemicals, refrigerants, spent formalin, antifreeze, oil filters, electronic wastes, and medical wastes. Many of these waste streams are managed through the City and County of Denver Environmental Health Department, except for electronics, refrigerants and medical waste. DZF maintains third party contracts to handle these waste streams.

Any materials that currently **cannot** be beneficially processed into fuel or does not have a recycling option within state of Colorado; these include, but are not limited to: construction generated waste, maintenance related waste, and some PVC plastics, will be land filled. Additionally, small quantities of hazardous waste will not be land filled but instead managed in accordance with applicable regulations for proper disposal and management.

(C) Description of procedures to be used for removal of Solid Waste or ash in event of breakdown

Ash removal

DZF has designed Equipment # 8-1,8-2,8-3 to be gravity fed and to control the out feed of ash through the use of internal components controlled by motors. The removal/evacuation of Equipment # 8-1,8-2,8-3 will be performed by lowering the restriction components and opening the gates at the base. This will entirely empty Equipment # 8-1,8-2,8-3 into the ash pit at the base of the specific units. The emptying of Equipment # 8-1,8-2,8-3 has to be controlled to allow the internal temperatures to drop below the combustion temperature of the solid fuel. Currently, the combustion temperatures of the solid fuel pellets have been tested to be approximately 500-600 F on a hot plate. The internal temperature readings of Equipment # 8-1,8-2,8-3 will have to be under 400 F in order for the gates to open to let all material pass through.

Ash will be removed from the ash pit by a third party contractor with a vacuum truck and hauled off for reuse at either a compost facility or utilized for another approved beneficial use. The designated beneficial use of the ash will be determined by the regular, representative testing of the ash to determine what it contains. Once consistent data on the ash has been collected, DZF will re-analyze if there is any change in the process, solid fuel mixture or as determined by DZF's Safety and Sustainability Departments.

In the case that the forklift used for transporting waste into the Denver Zoo Waste-to-Energy System has malfunctioned, back up equipment will be utilized to manage waste as needed. There are precautionary components and storage criterion that allows for equipment malfunction issues to be repaired given a specified quantity of time. The attendee/maintenance tech will be alerted of the issue and provided an estimate for the allowable amount of time before material will be required to be diverted by other means (primarily through the use of the roll-off compactors). The issues will all be logged and methods to fix the operation documented to improve performance of the plant using a custom built MRP system in development currently.

Other equipment within the facility may be required to be emptied in the event of a breakdown or regularly scheduled maintenance. Most of these equipment locations are listed below:

Equipment #1-1 through 1-5

This equipment is all readily assessable from outside and will require the use of either roll-off capable trucks and/or a bobcat to load material into roll-off containers for pick-up. DZF will maintain a contract with a third party company to provide hauling services and additional roll-off containers as needed and within the same day if requested.

Equipment #1-7, a, b, c

If power is available to the equipment, it can be turned on and material will be fed to a bin/container that will be placed between Equipment #1-8 and 1-9 to collect materials. If power is not available, then waste material will have to be removed by trained, qualified staff manually with the use of shovels and wheel barrows.

Equipment #5-0

This equipment is located above the pelletizer (equipment #5-1), if power is available material can be fed with the auger and by-pass the equipment #5-1 through a pass-through door. Material would have to be collected in smaller containers for removal manually (like 5 gallon buckets). This is only if power is available and the feed auger is operational.

If the feed auger is NOT operational, then material will have to be removed via a vacuum truck that would be provided by third party contractor. One of the top panels for the storage bin would be unbolted and the feed hose fed through to vacuum out the material. Material would be transported to landfill as solid waste. Communication with City and State will occur at this time, informing them of the breakdown and disposal pathway.

Equipment #7

Equipment #7 feeds the pelletized material out to the gasifier(s) but it can be directed back to the bin or to a separate bin if needed. The outlet of the storage bin is designed to have little internal moving parts and will be accessible for ease of replacing bearings, etc. If the motor/gearbox fails then an immediate replacement can occur. If power is available material can be fed through the out feed of the bin into a separate smaller bin that will have to be periodically moved using a pallet jack outside before being loaded onto a vehicle. The material will be collected in 4' x 4' x 4' boxes for loading and storage.

If power is not available and/or equipment is malfunctioning, then either a vacuum truck or manual removal of the material will be necessary. This would mean using the installed overhead crane to bring in material handling bins for manual filling and removal to be loaded in larger

boxes (as stated above) for disposal in landfill or temporary covered outside storage in bin S-5 (see Drawing M-1) if space is available.

Communication with the City and CDPHE will occur at this time to assist in determining best pathways. If necessary, the solid pelletized waste can ultimately be disposed of in landfill.

Equipment #9

Once this system is designed and further tested, DZF will be testing the scrubbing liquid to determine how to manage the liquid and permit requirements to manage the materials generated from this equipment. DZF will request assistance and approval for testing and proper disposal/handling of liquid waste with City Department of Environmental Health (City) as well as the Colorado Department of Public Health and Environment Solid Waste and Materials Management Division (CDPHE).

The City has requested updates and supplemental information with respect to the personnel responsibilities and availability information included in the existing EDOP. Section 11.2.4 (F) is hereby amended and restated as provided below.

(D) Safety, Fire prevention, contingency (see section 11.2.3 N)

(E) Provisions to not accept hazardous waste/approval of wastes

As part of DZF's Sustainable Management System (SMS), we maintain procedures for the management and proper disposal of hazardous and universal wastes, as defined by Federal and State regulations. These procedures were developed in partnership with the City and County of Denver Environmental Health Department (DEH). DEH manages the pick-up and disposal of DZF's hazardous and universal waste items in accordance with their Environmental Management System protocols and Federal, State and Local regulations. As it relates to additional waste generated by the waste to energy system, DZF has the financial and regulatory responsibility for all waste (hazardous, non-hazardous, sampling, analysis, disposal). DZF is a Conditionally Exempt Small Quantity Generator (EPA ID# COR000007625).

In addition, DZF will maintain partnerships with designated electronics recycling company, and other vendors for responsible recycling of electronics. As other recycling opportunities present themselves, we will maintain partnerships or contractual relationships with outside parties to properly divert materials from the landfill and the Denver Zoo Waste-to-Energy System.

DZF has conducted extensive site training with employees and volunteers to educate them on proper waste sorting practices to ensure low contamination rates at the point of delivery of waste at the Waste Management Building. Based on three years of waste studies conducted on guest waste at Denver Zoo, which makes less than 30% of the total waste volume, DZF is developing signage and training for Denver Zoo guests that will help ensure proper sorting at the point of waste disposal in our site. In addition,

DZF grounds personnel have been trained to look through waste bins prior to collection and grab any contaminants out of the waste stream.

The retail shops and employee buildings located at Denver Zoo maintain systems for recycling batteries that may be generated by guests, while they are on zoo grounds. These batteries are managed through DZF's waste program for Denver Zoo with City and County of Denver DEH.

In terms of upstream management of waste and in support of DZF's zero waste goal at Denver Zoo, DZF has also developed a proprietary software program that pre-screens all materials that are purchased on site to decrease level of contaminants in Denver Zoo's waste stream, support the development of solid fuel production, and reduce volumes of materials designated for landfill disposal.

Any materials obtained from an outside resource that have not already been accepted and tested as part of the current solid fuel mixture will require a pre-screening process to be performed by DZF Waste Management staff (which will be members of DZF's Facilities Group). This pre-screening will include description of waste, source of generated waste, physical location of waste, volumes, frequency, volume per delivery, waste handling practices or procedures associated with the waste, and potentially sampling data depending on the type of material. DZF at this time does not anticipate the addition of any other outside material not already approved as part of the current solid fuel mixture. An approval form will be developed and maintained in DZF's Sustainable Management System (SMS) program.

(F) Personnel Projected

DZF's grounds personnel are responsible for the collection and transportation of waste within Denver Zoo, including to the Waste Management Building. DZF's grounds personnel currently include personnel employed by DZF, as well as certain City employees assigned to Denver Zoo that are managed and supervised by DZF in accordance with the cooperative agreement between DZF and the City.

DZF will hire one to two full-time employees to oversee the Denver Zoo Waste-to-Energy System facility. These site specific employees will manage the processing of waste materials into solid fuel and the operation of the facility's components. Finally, these employees will be responsible for on-going preventative maintenance, compliance monitoring associated with applicable environmental regulations and permits, and site safety. Most of these requirements are defined in the OSWI EEEE permit documentation and required training and established "qualified" staff will be established. The staff will be on-call 24/7 and will have back-up assistance provided by the Special Projects and Maintenance Departments as needed. Anyone responsible as a back-up will be required to be trained according to OSWI EEEE 60.2905 – 60.2911.

DZF always has staff and security at Denver Zoo and part of their job requirement is to check on buildings nightly to confirm safety and security of the facilities. These staff will have completed review of information provided in OSWI EEE 60.2910. The Waste Management Building will be included in this

process and additional training may be required to assure that a thorough inspection is occurring on a daily basis.

(G) Hiring/Training Plan

DZF will utilize our Human Resource Department to establish hiring criteria, recruitment, and hiring of potential candidates for positions associated with this system. The criteria will consider all factors of compliance and safety of the system, and long term management.

The hiring process will occur once the equipment operation and installation is fully established. DZF will seek out mechanically inclined individuals with a history of operating/maintaining a plant or process line. Initially the operation of the facility will be managed by current DZF staff responsible for the design and development of the system. DZF staff will be working on the development of procedures and documenting/setting operational parameters.

When the DZF feels confident about the current status and operation of equipment we will also actively seek out a qualified individual who will assist with the development and design of database/user interface that will be either purchased and modified or custom built software/database package for tracking and monitoring: maintenance, operational schedules, replacement component data storage, unscheduled shutdown processes, and data storage and operational tracking. DZF believes that bringing someone in to assist in the development of the system will create ownership and will be built to suit their needs.

All hires will receive general zoo orientation training, Sustainable Management System (includes safety) training, and general equipment operational training will be provided by the DZF using the documentation built and the methods established from testing and development of the entire system.

(H) Nuisance avoidance measures (see drawing D-0)

Nuisance conditions are herein described as any condition where DZF receives an external or internal complaint regarding noise, odor, visual, debris or vectors. This section will describe DZF's process for responding to a complaint. A nuisance response flow chart is provided as drawing D-0. The following information provides further detail on how DZF will implement a response to a nuisance complaint and the control measures to reduce the occurrence of any complaints.

Management of this system in a manner that has minimal impact is critical for DZF not only to maintaining an enjoyable experience for guests to City Park but to the 2 million guests that annually visit the Denver Zoo and to DZF's animal collection at Denver Zoo. DZF with City (specifically DEH) assistance will promptly respond to odor and noise complaints from adjacent properties, including City Park, and also Denver Zoo guests. As outlined in DZF's nuisance response flow chart, we will immediately reassess the process to mitigate any odors or noise complaints.

Avoidance measures

DZF will maintain housekeeping protocols for the site and coordinate activities with DZF's Facilities Group. Housekeeping practices are important for proactively addressing the operation areas to reduce nuisance conditions, in addition to maintain a safe work area. Specific details on housekeeping (including timing, tasks, etc) will be continually improved upon as DZF understands where the need is required as to process operations.

The operation of the Denver Zoo Waste-to-Energy System is designed to mitigate any areas that could result in a nuisance condition. All exhaust points are controlled by air filtration systems that utilize both filters and carbon media. Waste is managed in a way that is not different from current management practices in terms of residence time in outdoor holding bins prior to conversion into energy. In addition, material handling equipment is enclosed to help cut down on dust generation for both housekeeping and safety purposes.

DZF is designing ways to insulate equipment to reduce noise and vibrations, which is critical to operating in close proximity to an animal exhibit and residential areas. These engineering controls will be maintained through regularly scheduled maintenance events and investigated in the event any noise complaints are received.

Response measures (see drawing D-0)

During normal working hours for Denver Zoo (8:00 a.m. to 4:30 p.m.), DZF Waste Management staff will respond to and investigate complaints as soon as possible, but not later than 12 hours after receipt of the complaint. After hours, weekend and holidays, complaints will be addressed by staff upon return to office. DZF Guest Services will also be provided emergency contact information for Waste Management staff in order to address any immediate concerns during these times.

Calls made into City and County of Denver 311, CCD-Department of Environmental Health or Parks and Recreation will be responded to and investigated as soon as possible, but no later than 24 hours after receipt of the complaint. City of Denver will notify DZF within the same time frame in order to provide Waste Management staff adequate time to respond and investigate the concerns. Reports made within the residential boundary of City Park will be investigated further by CCD- Department of Environmental Health. The Zoo with DEH assistance will promptly respond to odor and noise complaints from adjacent properties, including City Park, and also Zoo guests. Also, the Zoo will immediately reassess the WTE process to mitigate any odors or noise complaints. Measurements taken from these investigations will be reported to DZF and recorded in the nuisance complaint log.

Waste Management staff will take reasonable measures to investigate and remediate any reported nuisance condition within a timely manner. In addition, a record of nuisance conditions will be maintained by the Waste Management staff in the Nuisance Complaint Log. (This log will record date and time of nuisance condition, contact information of the individual that reported the condition, cause of nuisance, actions taken to remedy, and whether contact was called back to report corrective action.

(I) Inventory and location of facility records and built drawings

The inventory and location of facility records will occur on two sides, one digital and one hard copy. All records will be stored in the DZF's Sustainable Management System database, which is monitored and audited on a yearly basis. All suggested adjustments, etc. will be implemented to improve safety and performance of the facility.

Each piece of equipment will have an 11" x 17" equipment booklet that will store equipment drawings, starting with the larger assembly and working down to individual components. A bill of materials (BOM) will store every part that was used on the equipment in case of replacement. For components that have cut sheets, such as sensors, motors, and bearings one will be included. These books will be numbered to correspond to each and delineate equipment in the overall assembly.

Digitally, identically information will be stored in a custom built database. The main purpose of this database is to track the replacement and maintenance of equipment and will be considered the "up-to-date" version of the equipment booklets. The database will print out daily maintenance lists and a calendar will schedule the maintenance to minimize planning by the facility operator.

Again, to ensure that the database and the equipment books are up to date, they will be a part of DZF's Sustainable Management System (SMS) and will be audited bi-annually as is required by ISO-14001.

(J) Provisions for monitoring

In 2009, DZF's Sustainable Management System received ISO 14001 certification. DZF maintains this system to manage DZF's environmental practices and procedures on site at Denver Zoo. As part of this system, DZF maintains comprehensive monitoring and measurement of all operations. DZF's monitoring efforts will be managed within the SMS as developed by the DZF's Sustainability Manager in coordination with the Waste Management team.

Records will be provided to CDPHE upon request by the Department, taking into consideration any records that are Confidential Business Information of DZF. Additionally, DZF will submit on an annual basis, specific records (to be defined and agreed between DZF and the City), electronically, to the City, taking into consideration any records that are Confidential Business Information of DZF. See section above titled "Confidential Business Information." In addition, representatives of DZF and the City's Department of Environmental Health (DEH) will meet at times mutually agreed (at a minimum, on an annual basis) to ensure requirements of the Certificate of Designation are being met. Meetings may include tours/inspections of the Denver Zoo Waste-to-Energy Facility. Records of these meetings, including any tours/inspections, will be maintained in DZF's SMS program, and any issues identified will be tracked using DZF's corrective and preventative action process.

Monitoring associated with this system will include, but are not limited to:

- a. Air Quality permit monitoring requirements
- b. Waste-to-Energy Operation parameters

- a. Waste volumes in hoppers
- b. Throughput of processing equipment
- c. Energy use (kWh) per piece of equipment (single monitor moveable – estimation)
- d. Ash testing for waste determination per RCRA – TBD based upon initial evaluation
- e. weight records and material evaluations
- c. Upset and Nuisance conditions
 - a. Bridging and/or material build-up
 - b. Odor evaluation
 - c. Dust detection and evaluation
 - d. Noise (dB) evaluation
 - e. Temperature/contact issues
 - f. Upset/nuisance condition log (record internal and external complaints)
- d. Regulated Materials Management (waste volumes from CCD-Environmental Health)
- e. Employee and Volunteer Training (waste sorting, maintenance, safety, etc)
- f. Spill Response Reporting
- g. General site housekeeping inspections and records
- h. Equipment maintenance schedules (MRP system)
 - a. Unscheduled breakdown/maintenance of equipment (time/date/issues/solution)
 - b. Repair component – duration, access issues, etc., breakdowns, repairs, and procedures will be documented in a custom zoo MRP system
 - c. Scheduled maintenance-
 - i. Replacement of gear oil/bearings/cooling fluid
 - ii. Replacement of consumable parts
 - iii. Cleaning of equipment and evaluation of operation
 - iv. Grease bearings
 - v. Change out filtration components
 - vi. Test/replace sensors
 - vii. Pressure test for air/liquid leaks
 - viii. Replace gaskets
 - ix. General clean-up and touch-up of paint
- i. Equipment inspections will occur weekly and the facility operator will be responsible for noting any issues that are apparent and differentiate from “normal” operation.
- j. Annual DEH certificate of designation site regulatory audit records (inspections, corrective actions).

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