

## Technical Memorandum: Wastewater Treatment Residuals Management

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**1.0 BACKGROUND AND INTRODUCTION**

The purpose of this memo is to characterize the alternatives for wastewater residuals management as part of Google’s Downtown West Mixed-Use Project (Project) in the Diridon Station area of San José, California and to advance the conversation towards selecting an alternative. Residuals management is a critical consideration of the wastewater treatment process. Like many other “waste” products there are costs and regulations associated with disposal and/or treatment, as well as interventions that may be implemented for waste minimization and resource recovery. The major considerations for implementation are explored herein. This memo:

- Characterizes the anticipated wastewater residuals
- Estimates residuals loading
- Outlines the regulatory framework for residuals management
- Describes alternative residual treatment trains
- Estimates resource recovery potential
- Evaluates costs for each alternative

Three solids management alternatives as summarized in Table 1. The first treatment residual management alternative considers sending solids generated to the City of San José for treatment. The second alternative considers anaerobic digestion of wastewater solids to provide cost, energy and nutrient recovery for the Project. The third alternative considers co-digestion of wastewater solids and source-separated food waste for increased production of biogas and biosolids which can provide increased resource and cost recovery for the Project. To progress the wastewater treatment planning and design into the next stage, a path forward on incorporating one of the solids management alternatives into the Project must be selected.

Once dewatered and/or treated, wastewater residuals will need to be transported for disposal or beneficial reuse. The environmental impact of hauling dewatered residuals may need to be evaluated for CEQA purposes. Residuals production is quantified herein to facilitate estimating the number of truck trips required.

**Table 1:** Summary of three alternative solids management strategy approaches for the Project.

Alternative	Description
1	Discharge solid residuals to the sanitary sewer; allow for future solids management capacity to be appended to the proposed treatment process
2	Solid residuals from the wastewater treatment process are anaerobically digested to produce biogas and Class A biosolids
3	Solid residuals from wastewater treatment process are co-digested with source separated food waste to produce more biogas and Class A biosolids

## 2.0 WASTEWATER AND RESIDUAL SOLIDS CHARACTERIZATION

### 2.1 Influent Wastewater Characterization

The Project is expected to produce approximately 780,000 gallons of wastewater on an average day and approximately 970,000 gallons per day during maximum occupancy. The proposed district water reuse facility (WRF) will receive wastewater produced from different program uses across the Project area, including from: residential units, office spaces, hotels, and commercial establishments including restaurants and shops. Wastewater produced by each site/parcel can differ substantially with respect to solids content and chemical loading. More details on the wastewater flows broken down by program are available in the [Water Reuse Basis of Design TM](#). Constituent loading and influent concentrations to the proposed water reuse facility are summarized in Table 2.

**Table 2:** Anticipated concentrations and daily loading of wastewater constituents for the Project.

Wastewater Constituent	Average Day		Max Day	
	Load [lb/d]	Concentration [mg/L]	Load [lb/d]	Concentration [mg/L]
BOD	3,100	480	4,100	500
TSS	3,300	510	4,100	510
Total N	500	76	630	78

Note: Values represent commingled wastewater collected from all program areas throughout the Project. List of acronyms: WW, wastewater; BOD, biochemical oxygen demand; TSS, total suspended solids; N, nitrogen.

### 2.2 Residual Solids Characterization

Wastewater arriving at the plant will be processed by the proposed wastewater treatment train. The unit processes that will produce residual solids include: screening and grit removal, primary solids removal and secondary biological treatment with tertiary filtration. These residual solids will all require an appropriate management strategy. Below is a brief description of each unit process and the associated residual generation.

#### 2.2.1 Screening and Grit Removal

Preliminary screening of wastewater is intended to remove large materials from the flow stream that may damage or clog subsequent treatment equipment, and reduce overall treatment reliability. Screens can either be coarse or fine depending on the size of material intended for removal. Materials captured by the screens are called screenings and can include rags, plastics, and paper. Screenings are composed of primarily inorganic wastes that are not biodegradable and not beneficial for post processing and resource recovery. As such, screenings are typically washed, compacted and hauled off site at regular intervals for disposal in a permitted landfill.

Grit such as sand, gravel, coffee grounds and egg shells are removed to prevent their accumulation in downstream processes such as aeration basins and anaerobic digesters. These materials are typically removed via gravity settling; scour air or another abrasion process can be used to more effectively separate grit from other suspended solids. Similar to screenings, grit does not have a resource recovery value and are hauled off site.

#### 2.2.2 Primary Treatment

Primary solids removal from the influent wastewater is typically achieved by gravitational settling of solids and floating material in large tanks called clarifiers. Primary filtration is an alternative technology for solids removal and requires a smaller footprint as compared to clarifiers. Whereas primary clarification results in a relatively dilute solids stream (1 to 4% solids depending on operations), primary filtration produces a solids “cake” that is not flowable and contains between 15 and 25% solids.

Primary solids are high carbon content organic solids that have a high energy recovery potential. Primary treatment can remove from 50% to 80% of suspended solids and 25% to 40% of biochemical oxygen demand (BOD) from influent

wastewater. Where higher removal rates of solids and BOD are achieved, the reduced loading can reduce the size of downstream processes and have a beneficial impact on the energy balance of wastewater treatment.

### 2.2.3 *Secondary Treatment and Tertiary Filtration*

Secondary (biological) treatment typically utilizes aerobic microbes to remove chemical, colloidal, and organic substances from wastewater. The aerobic microbes produce biomass, called activated sludge, as a result of the treatment process. Because the solids produced at this stage are composed primarily of cell mass, they are different from the raw wastewater solids generated by primary treatment. As a result, secondary solids are less odorous than primary solids but also have less energy recovery potential by weight.

Municipal wastewater treatment plants typically utilize secondary clarifiers to separate these solids. The basis of design treatment train as outlined in the [Water Reuse Basis of Design TM](#), includes a membrane bioreactor (MBR). In an MBR process, activated sludge is separated using membranes submerged in the final zone of the bioreactor. Membrane separation allows for a higher concentration of activated sludge microorganisms to be grown within the secondary reactor. This higher concentration of biologically active solids inventory and the integration of submerged membranes with the secondary reactors reduce the footprint of MBRs compared to conventional activated sludge.

When suspended in an activated sludge bioreactor, these solids are called mixed liquor suspended solids (MLSS). An MBR process will typically operate at a MLSS concentration between 8,000 and 15,000 mg/L; operating values are adjusted by the wastewater operator based on process performance. Some of these solids are returned to the bioreactor as return activated sludge (RAS) to maintain microbial activity while a steady stream is removed from the process as waste activated sludge (WAS). Management of WAS is a primary focus of this memo.

## 2.3 *Summary of Regulatory Requirements*

### 2.3.1 *Sanitary Sewer Discharge*

A permit from the City of San José will be required for the Project to discharge into the sanitary sewer. Under Alternative 1, the City may require the acquisition of an industrial wastewater discharge permit for the Project. This permit allows the City to recover some of the capital, operations, and maintenance costs associated with the increased operation of the wastewater treatment plant due to increased loading in the sanitary sewer. Charges associated with the permit are proportional to the volume of discharge, chemical loading, and solids loading. The City of San José does not list any maximum threshold of solids or chemical disposal into the sanitary sewer according to the San José Code of Ordinances Section 15.14, Part 3. Under Alternatives 2 and 3, the City may permit the Project under one of its 63 standard classifications of commercial users due to minimal sewer discharge. Permits can be acquired after contacting the City's Public Works Development Services staff.<sup>1</sup>

### 2.3.2 *Screenings and Grit Handling and Disposal*

Applicable regulations for the handling and disposal of screenings generated from wastewater pretreatment are dictated by the City of San José, the Regional Bay Area Air Quality Management District, and the Regional Water Quality Control Board. Screenings and grit collected from the treatment process will contain fecal matter presenting a potential threat to public health. The screenings and grit would need to be managed to not create nuisance odors; wastewater treatment plant odors are subject to the jurisdiction of the Bay Area Air Quality Management District.<sup>2</sup> Handling and disposal would require screenings and grit to be washed and drained, and the wash water may be recycled to the front of the treatment train. Once washed and dewatered, the screenings and grit will be stored in refuse containers satisfying the City's requirements, and routinely hauled offsite to a permitted landfill. Refuse containers would have to be odor proof and contained within an area draining to the sanitary sewer in the case of a rain event.<sup>3</sup> These measures are meant to reduce impacts on the surrounding community.

### 2.3.3 *Biosolids Classifications*

The anaerobic digestion of the treatment solid residuals will produce stabilized biosolids. The classification, handling, reuse, and disposal of biosolids fall under the USEPA's regulations and is promulgated in California by the Regional Water Quality Control Board. The 40 Code of Federal Regulations, Part 503 regulates biosolids and specifically applies to

<sup>1</sup> <https://www.sanjoseca.gov/index.aspx?NID=1649>

<sup>2</sup> <http://www.sanjoseca.gov/FormCenter/Code-Enforcement-21/Odor-Complaint-Form-315>

<sup>3</sup> <https://www.sanjoseca.gov/DocumentCenter/Home/View/437>

land application, surface disposition, pathogen and vector reduction, and incineration. In order to determine how biosolids are managed, a threshold for pathogen and vector attraction reduction has to be met. The threshold created by the EPA distinguishes biosolids between Class A and Class B biosolids. Class A biosolids are considered safe for use by the general public, gardens, and golf courses based on meeting a maximum pathogen detection level of either fecal *Coliform* or *Salmonella*, and meeting one of four time-temperature regimes during digestion.<sup>4</sup> Specific guidelines for the creation of Class A biosolids can be found in section 503.33(b) of the EPA regulations.<sup>5</sup> Class A biosolids are the intended byproduct of the proposed anaerobic digester as they are a safe and potentially marketable product, which would allow for the beneficial reuse of the treated solids and to a lesser degree would help to offset the costs of installing and operating an anaerobic digester.

### **3.0 SOLIDS MANAGEMENT**

#### **3.1 Residuals Production**

Treating wastewater will generate a proportional volume of residuals. A proper management strategy for these residuals will need to consider space, costs, and applicable regulations relevant to their handling and disposal. Wastewater treatment solid residuals volumes are listed in Tables 3.1 and 3.2 below.

##### **3.1.1 Screenings and Grit (Preliminary Solids)**

The volume of residuals generated by preliminary screening removal is based on size and efficiency of the equipment. A fine screen will produce a higher volume of screenings than a coarse screen. A fine screen located in the headworks of a municipal wastewater treatment plant with a 6 mm spacing typically produces 0.35 yd<sup>3</sup> of waste per million gallons of wastewater<sup>6</sup>. This size screen is equivalent to the largest pore size for a fine screen and the smallest for a coarse screen. Assuming a similar screen size is used at the proposed WRF, a volume of approximately 2 cubic yards of screenings will be produced per week on average, and no more than 2.5 cubic yards per week of screenings will be produced during maximum occupancy.

It is estimated that the total volume of grit produced weekly will not exceed 0.5 cubic yards. Therefore, the anticipated total screening and grit to be hauled away weekly can be estimated to be about 3 cubic yards.

##### **3.1.2 Primary Solids**

Primary solids removal utilizing a settling tank at a municipal wastewater treatment plant typically removes about 50% of all suspended solids entering the tank. At daily average flows, this removal rate will result in approximately 1,700 lbs/day of dry primary settled solids being produced or 20 cubic yards per week for average wastewater flows. Primary solids removal can also be achieved by utilizing a filtration system that can remove between 30% and 80% of suspended solids. The upper range of solids removal by filtration will result in approximately 2,700 lbs/day of dry primary solids being produced or 52 cubic yards per week for average wastewater flows assuming a 20% solids content in the residual solids. Peak wastewater flows will generate approximately 3,300 lbs/day of dry primary solids or 64 cubic yards per week. See alternative evaluation below for a discussion of primary solids management options.

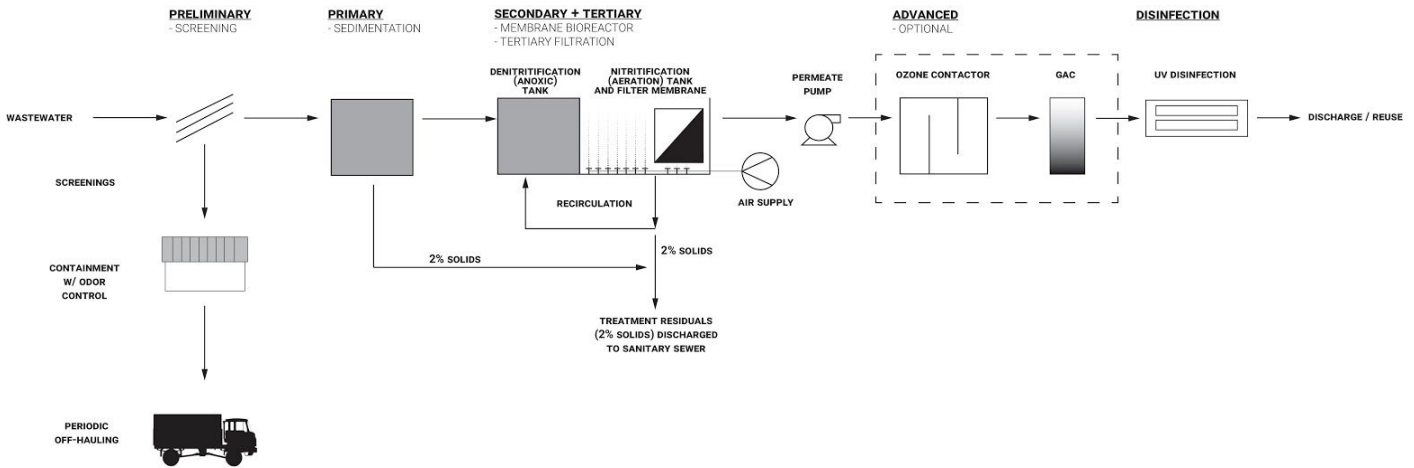
##### **3.1.3 Secondary Solids**

Secondary solids consist of the MBR wasting stream (WAS) and are a function of organic loading (e.g., BOD). The total secondary solids are preliminarily estimated to be 3300 (average) to 4200 (max) lb/d, or 40,000 (average) to 51,000 (maximum) gallons per day of 1% (10,000 mg/L) total suspended solids flow. As the Project enters the design phase, a biological process model should be built to validate these values. Organic and nitrogen loads associated with this wasting stream can be characterized upon system start-up should it be necessary to estimate discharge fees.

<sup>4</sup> <https://www3.epa.gov/npdes/pubs/owm0031.pdf>, Table 5-3

<sup>5</sup> Tchobanoglous, George, et al. *Wastewater Engineering: Treatment and Resource Recovery*. Fifth edition, 2014.

<sup>6</sup> Tchobanoglous, George, et al. *Wastewater Engineering: Treatment and Resource Recovery*. Fifth edition, 2014.



**Figure 1:** Process flow diagram of showing residual management Alternative 1. ([Click here to enlarge figure.](#))

**Table 3.1:** Mass of dry solid residuals produced with regards to unit treatment process and wastewater flow scenario.

Treatment Process	Dry Solids Produced [lb/day]	
	Average	Peak
Flow Regime		
Preliminary	500	600
Primary Settling	1,700	2,100
Primary Filtration	2,700	3,300
MBR	3,300	4,200

Note: Solids production from section 3.1 is summarized here.

**Table 3.2:** Volume of solid residuals anticipated to be produced with regards to treatment process and wastewater flow scenario.

Treatment Process	Units	Volume of Solids	
		Average	Peak
Flow Scenario	-		
Preliminary	cu yd/week	2.4	2.9
Primary Settling	gal/day	10,200	12,600
Primary Filtration	gal/day	1,500	1,900
MBR	gal/day	40,000	51,000

### 3.2 Anaerobic Digestion

In anaerobic digestion, wastewater solids are broken down by microorganisms in an oxygen deficient environment. Solid residuals are preprocessed, and regularly fed to the reactor. Anaerobic digesters operate in two regimes: mesophilic or thermophilic. Mesophilic digestion operates between 85 and 100 °F (29-38 °C), while thermophilic digestion operates between 120 and 135 °F (49-57 °C). There are advantages and disadvantages of one process over the other, namely the ease of achieving Class A biosolids certification, operational differences, and spacing requirements. It is yet to be determined which of these processes will be best suited to the solids treatment process. It is possible that an alternative onsite solids management process will be pursued. Anaerobic digestion is used as the basis of design because it is the most typical solids management process and allows for energy recovery.

Preprocessing is utilized to achieve greater efficiency in anaerobic digestion. Preprocessing can include source separation, dilution, grinding, thickening, and grit removal to allow for better operation of the digester as well as processes meant to increase the efficiency of microbial reactions within the digester. For example, preprocessing can increase energy yield by breaking down the outer membrane of the microorganisms utilized in secondary treatment, called lysing, which would not otherwise decompose well in an anaerobic environment. There are two widely used practices for lysing cell membranes: thermal hydrolysis, and physical/chemical/electrical pretreatment. Thermal hydrolysis is the process of removing water from the solids and heating them to temperatures upwards of 329°F (165°C). The latter pretreatment practice can be achieved by a variety of methods ranging from electric shocks, pressurization, mulching, and chemical addition like lime to weaken the cell membrane. In addition to achieving more efficient digestion, pretreatment can help to achieve Class A biosolids classification following treatment. It is typically utilized in conjunction with mesophilic digestion to meet the Class A requirements.

In general, once solids are applied to the digester, they are constantly mixed and heated for 15-20 days to facilitate the digestion of solids and to produce biogas. This time scale is the typical operating condition at municipal facilities because it is the minimum time necessary to meet biosolids classification requirements. Following anaerobic digestion, solids are typically thickened and dewatered prior to post-processing for beneficial reuse or final disposal. A mesophilic digester will not be able to produce Class A biosolids without preprocessing while a thermophilic digester may be able to achieve the Class A with minimal preprocessing.

Biogas formed in the reactor must be processed to remove contamination, called scrubbing, before it can be used to generate electricity. Excess water extracted from the biosolids dewatering process, called dewatering return flow, usually contains a high concentration of nutrients, such as phosphorus that could potentially be harvested and beneficially reused. Technologies aimed at increased resource recovery from wastewater treatment residuals will be discussed further in section 3.7.

### **3.3 Anaerobic Co-Digestion**

There is potential to comingle food waste and other organic waste collected from the Project into the wastewater solids anaerobic digester to augment the feedstock quantity and increase the energy recovery potential of the system. This process is commonly referred to as co-digestion. Introducing organic waste into the biosolids treatment train will necessitate some preprocessing to optimize the performance of the digester similar to what was described in section 3.2.<sup>7</sup> In order to utilize food waste for co-digestion, there are many factors to consider including: source contamination, transfer of organics, and necessary preprocessing.

Organic food waste is typically made up of food scraps and the increasingly popular compostable foodware and packaging (CFP). Food waste generated by food production facilities within the Project (mostly central kitchens within Google office buildings) is anticipated for incorporation into the anaerobic digestion process, though all organic waste may also be collected. This source separated food waste is typically much less contaminated than organic waste collection bins accessible to the general public.<sup>8</sup> Contamination is caused by non-organic garbage and recyclable materials being placed in the organic waste collection bins. These materials can have negative impacts on the preprocessing and digestion units, and will need to be removed either through source separation or some other trash removal process employed after transfer to the digestion facility. Source separated food waste could be collected by means of pneumatic trash collection as part of the automatic waste collection system (AWCS), vehicle hauling, or routing through the private sanitary sewer system.

CFP is a popular replacement for single-use plastics used to transport and consume food. It includes foodware like cutlery, cups, plates, and take-out containers that can be made up of bioplastics, wax-lined cardboard, and other cardboard-like materials. Municipalities in the Bay Area have banned single-use plastics leading to the use of CFPs as an alternative. To reduce plastic waste, Google utilizes both reusable foodware and cutlery as well as CFP.

Because CFPs are expected in organic waste streams collected throughout the Project, it is important to understand how they may behave within the context of solids management Alternative 3 discussed in this memo. A study conducted at

<sup>7</sup> <https://archive.epa.gov/region9/waste/archive/web/html/ebmud-process.html>

<sup>8</sup> Circularity review MAT1-3 Preliminary Findings, July 2019

Ohio State University (2013) tested the feasibility of anaerobically digesting bioplastics.<sup>9</sup> In the study, research into the biodegradability of food waste and bioplastics in an anaerobic digester was explored. It was determined that the degradability timescale of bioplastics is beyond the timescale for conventional anaerobic digestion (15-20 days), and the energy potential is too variable and likely very low in an anaerobic digester. The study did not test the other materials commonly used in CFP; nonetheless, there is little published research into CFP's behavior in an anaerobic digester. CFP that does not biodegrade can contaminate the biosolids generated by the digester or negatively impact microbial activity.

As coordinated with the Arup logistics team, it is possible to separately collect high energy potential food waste using the AWCS system. Therefore, it is assumed that CFPs would not be included in this waste stream. Due to these findings, CFP is left out of the energy potential calculations for the following solids management alternatives.

### **3.4 Alternative 1: Discharge to Public Sanitary Sewer**

Primary and secondary organic solids can be discharged to the sanitary sewer for treatment at the San José-Santa Clara Regional Wastewater Facility. Discharge will incur charges under the monitored industrial rates administered by the City of San José. This management strategy has recurring costs associated with discharge to the sanitary sewer as discussed in section 2.3.1. The maximum volume charge expected on an annual basis is expected to be \$160,000 and the loading charge is expected to be approximately \$90,000, \$350,000 and \$40,000 dollars for BOD, solids, and nitrogen loading, respectively. The total annual fees would be approximately \$640,000 for residual solids discharged to the public sanitary sewer. No equipment beyond what is required for wastewater treatment would need to be installed; however, space could be reserved and pipe connections could be stubbed out to facilitate residual solids treatment and reuse of biosolids onsite in the future.

Alternative 1 would necessitate the use of primary settling over primary filtration because the solids must be pumpable to be discharged. Note that primary settling is less effective than primary filtration and as a result may require a larger MBR process downstream.

### **3.5 Alternative 2: Onsite Wastewater Solids Management**

Alternative 2 considers the use of anaerobic digestion, as described above, for the treatment and beneficial reuse of wastewater solids. While contained in the digester, one of the four time-temperature regimes required by the EPA will be implemented to produce Class A solids. The appropriate regime is dependent on the solids content applied to the digester and preprocessing. After solids are removed from the digester they must be dewatered prior to beneficial reuse as a soil amendment. The excess water from dewatering may be rerouted to the front of the plant for dilution into the wastewater treatment stream, or it can be utilized for its high nutrient content by incorporating one of the innovative resource recovery technologies discussed below.

Biogas collected from the digester can be used to generate electricity after processing through the utilization of a hydrogen fuel cell. While internal combustion of biogas is the current practice for generating electricity and heat from biogas (co-gen), the Project plans to eliminate such combustion processes. Fuel cells are an emerging technology that may reduce the necessary footprint associated co-gen as well as reduce direct emissions of greenhouse gases into the atmosphere. The estimated range of energy produced by digestion of wastewater alone is between 2,000 and 4,000 kWh per day of average wastewater flow as listed in Table 4.1. Therefore, the onsite digestion of wastewater solids could supply enough energy to offset 35% to 75% of the energy demand of the district WRF including wastewater collection and recycled water distribution. See [Water Reuse Basis of Design TM, Section 5.6](#) for an estimate of overall energy demand for wastewater treatment.

### **3.6 Alternative 3: Onsite Wastewater and Food Waste Solids Management**

The difference between Alternatives 2 and 3 is the incorporation of source separated food waste into the digestion process. This treatment strategy would employ a state of the art anaerobic digester for co-digestion. Source separated organic food waste will have to be transported to the wastewater treatment area and can be achieved by the methods discussed previously. If transported through the AWCS system, it may be directly applied to a pre-processing unit or to a storage container which would then supply the pre-processing unit. Pre-processing before introduction to the digester entails grinding the waste. Source separation of food waste from the food preparation facilities and general use areas will

<sup>9</sup> Anaerobic digestion of bioplastics: [https://etd.ohiolink.edu/!etd.send\\_file?accession=osu1385467507&disposition=inline](https://etd.ohiolink.edu/!etd.send_file?accession=osu1385467507&disposition=inline)



reduce contamination that could accompany this waste stream, keeping residuals from this stream to a minimum. The pulp resulting from grinding of the food waste may be pretreated further with the wastewater solids or directly applied to the anaerobic digester for treatment. The digester operation and post-digestion solids management will be very similar to Alternative 2 except the volume of feedstock will be much higher by incorporation of food waste.

The estimated range of energy produced by co-digestion of wastewater and source separated food waste is between 4,500 and 8,200 kWh per day of average wastewater flow as listed in Table 4.1. Preliminary energy calculations indicate that the onsite digestion of wastewater treatment plant residuals combined with food waste could result in a net positive energy balance for the WRF including wastewater collection and recycled water distribution. Energy use associated with the collection of food waste and that associated with solids off-hauling for disposal or beneficial reuse are not included in this evaluation. As the project progresses into the design phase, the overall WRF energy balance should be refined.

**Table 3.3:** Volume and energy of biogas produced daily at steady state by anaerobic digestion.

Feedstocks	Biogas Produced [standard cubic feet]		Energy [kWh per day]	
	LOW	HIGH	LOW	HIGH
Range				
Wastewater Solids	18,800	37,600	2,000	4,000
Food waste	22,900	39,700	2,500	4,200
Total	41,700	77,300	4,500	8,200

**Table 3.4:** Volume and energy of biogas produced annually at steady state by anaerobic digestion.

Feedstocks	Biogas Produced [standard cubic feet]		Energy [kWh]	
	LOW	HIGH	LOW	HIGH
Range				
Wastewater	2,350,000	4,700,000	250,000	500,000
Food waste	8,360,000	14,490,000	880,000	1,530,000
Total	15,221,000	28,215,000	1,643,000	2,993,000

### 3.7 Innovative Technologies

Given that resource recovery is an ever-evolving field, it is important to maintain the ability to expand and/or modify the treatment process to account for technological advancements, modifications to regulations, and changing priorities. Future-proofing in the context of wastewater residuals management means having the ability to recover energy, nutrients, and biomaterials from the treatment process. Innovative technologies like a pyrolysis process for the creation of biochar, or biosolids collection for the creation of PHA (for manufacturing bioplastics) can offer future alternative solids management strategies in place of or in addition to anaerobic digestion. Other strategies can also provide revenue generation to offset the costs of onsite management such as phosphorus recovery from the precipitation of struvite. This practice works to create a closed loop solution for wastewater production as well as provide a sustainable solution for the production of fertilizers. Harvesting struvite from wastewater also has the potential to reduce maintenance costs by reducing the scaling of struvite in pipes.<sup>10</sup> Future interventions can reduce costs associated with disposal and create valuable offsets to technological investment. These innovative technologies will be explored further as the Project progresses into the design phase.

<sup>10</sup> Zhang, Tao, et al. "Phosphorus Recovery by Struvite Crystallization from Livestock Wastewater and Reuse as Fertilizer: A Review." *Physico-Chemical Wastewater Treatment and Resource Recovery*, May 2017. www.intechopen.com, doi:10.5772/65692.

#### **4.0 COST COMPARISON**

The cost of each alternative was estimated to assist in providing direction moving forward. This cost comparison does not take into account: capital costs for construction of the wastewater treatment system and recycled water distribution system, additional spacing requirements (building, land value) that may need to be considered for installation and operation of equipment, costs of transporting food waste to the digestion facility, costs differences between mesophilic and thermophilic digesters, and costs of pre/post-processing necessary to utilize biogas and biosolids produced by the digester. Capital costs, operating costs, and energy savings for the different alternative solids management scenarios are summarized in the list below.

##### **4.1 Alternative 1: Discharge to Public Sanitary Sewer**

Under current sewer rates, the estimated annual cost to discharge solid residuals to the sanitary sewer is approximately \$640,000 per year. Assuming an annual incremental increase in fees of 3%, the total amount of operational cost for Alternative 1 over 20 years is estimated to be \$17 million dollars. As a point of comparison, the estimated energy cost to operate the WRF without any potential energy recovery is estimated to be \$1.9 million dollars following the same fee increase assumptions.

##### **4.2 Alternative 2: Onsite Wastewater Solids Management**

The basis of design system for this cost comparison is the Impact Bioenergy “Nautilus” model anaerobic digester. Due to the solids loading anticipated for the Project, several systems may need to be installed to meet Project needs. The cost to install an anaerobic digestion system to treat the volume of wastewater solids generated by the Project under Alternative 2 is approximately \$1 million dollars. This is the approximate price for one digester unit (equipment only). The annual O&M costs are estimated to be \$50,000. The equivalent annual cost (EAC) to operate and maintain the onsite anaerobic digester is estimated to cost \$1.3 million dollars over 20 years. The potential energy savings to operate the WRF over a 20-year period is estimated to be almost equivalent if the high energy production scenario in Table 4.1 is considered.

##### **4.3 Alternative 3: Onsite Wastewater and Food Waste Solids Management**

The cost to install an anaerobic digestion system onsite with the ability to co-digest the volume of wastewater solids and food waste generated by the Project is approximately \$3 million dollars. The annual O&M costs are estimated to be \$150,000. The EAC to operate and maintain the onsite anaerobic digester is estimated to be \$4 million dollars over 20 years. The potential energy savings to operate the WRF over a 20-year period is estimated to be \$1.9 million dollars if the high energy production scenario in Table 4.1 is considered. This will result in a complete offset of energy costs for operating the WRF.

#### **Solids Management Alternatives Cost Analysis**

1. Discharge to Public Sanitary Sewer
  - a. Sewer Rates per year: \$640,000
  - b. Total Sewer Costs in 20-year Period: \$17 million
  - c. Total WRF Energy Costs in 20-year Period: \$1.9 million
  
2. Onsite Wastewater Solids Management
  - a. Anaerobic Digestion (AD) Capital Costs: \$1 million
  - b. AD Operating Costs per year: \$50,000
  - c. AD Operating Costs in 20-year period: \$1.3 million
  - d. WRF Energy Costs savings in 20-year period: \$800,000
  
3. Onsite Wastewater and Food Solids Management
  - a. Anaerobic Digestion (AD) Capital Costs: \$3 million
  - b. AD Operating Costs per year: \$150,000
  - c. AD Operating Costs in 20-year period: \$4 million
  - d. WRF Energy Costs savings in 20-year period: \$1.9 million

## 5.0 SUMMARY AND CONCLUSIONS

The Project is expected to produce 780,000 gal/day of wastewater on average and up to 970,000 gal/day during peak scenarios. Associated residuals from treating the wastewater include: screenings and grit, primary treatment solids, and secondary treatment solids. Screenings and grit provide no beneficial reuse and require disposal in a landfill. Management of primary and secondary solids can either be left to the municipal authority by means of discharging to the public sanitary sewer or managed on site using anaerobic digestion as described in section 3.5. Advantages of the anaerobic digestion system include cost recovery through energy generation, solids recovery, and reduced discharge to the public sanitary sewer. Disadvantages to utilizing the system include additional space necessary for treatment, capital costs for pre/post-processing, and dedicated operations staff.

If there is a desire to increase the energy and solids recovery of the digesters, incorporating food waste into the anaerobic digestion process may be a viable option. Increased biogas production would offset the energy utilized by the water reuse facility, and increased solids production would increase the revenue from marketing of potential fertilizers. Advantages of this alternative management strategy include: potentially energy positive WRF, reduced waste disposal costs, and reduced discharge to the public sanitary sewer. Disadvantages include: high capital costs, increased operational costs due to incorporation of food waste, and increased space requirements to include additional digesters.

In order to advance the Project into the design phase, one of the three solids management alternatives presented herein should be selected. Given the interdependence of wastewater system design and the management of residuals, the selected alternative will inform the overall wastewater system design. Should Alternative 1 be selected, coordination with the City of San José will begin immediately to better understand any potential impacts to their sanitary sewer.