SOUTH ORANGE COUNTY WASTEWATER AUTHORITY

COASTAL TREATMENT PLANT
SLUDGE EXPORT REPLACEMENT PROJECT

ON-SITE SLUDGE PROCESSING ANALYSIS

FINAL
June 2012

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1.0 INTRODUCTION

The South Orange County Wastewater Authority (SOCWA) owns and operates four wastewater treatment plants. The Coastal Treatment Plant (CTP) consists of a conventional activated sludge secondary treatment plant with a rated capacity of 6.7 million gallons per day (MGD).Other than thickening, the primary sludge, and waste activated sludge (WAS) are not treated on-site. The combined sludge is pumped to the Regional Treatment Plant (RTP) for thickening, anaerobic digestion, dewatering, and ultimate off-site beneficial use.

The sludge is pumped through one of two, parallel 4-inch force mains. Only one is needed at a time, the second serves as a backup. The 4.5-mile long force mains are approximately 25 years old and are approaching the end of their useful life. Replacement with new force mains or an alternative sludge handling method is required.

The Export Sludge Force main Pre-Design Report (PDR) evaluated three viable alternatives. These include:

- Alternative FM1: New force main alignment located east of Aliso Creek, following the existing Effluent Transmission Main easement.
- Alternative FM2: New force main alignment located west of Aliso Creek within the existing paved areas of Aliso Water Management Agency Road.
- Alternative TR1: Hauling liquid sludge from the CTP to the RTP in tanker trucks.

These alternatives are being evaluated as part of the PDR as they are anticipated to require the least amount of time to implement. Additional alternatives that may be evaluated include solids handling at the CTP.

2.0 PURPOSE AND SCOPE

The purpose of this technical memorandum (TM) is to identify, develop, and evaluate alternatives consisting of on-site sludge treatment. This alternative is referred to as SH. It will be compared to the others with respect to cost and environmental impacts.

The scope for this TM consisted of the following tasks:

- Determine the sludge characteristics in conjunction with Alternative TR1.

- Identify two potential process trains that will allow off-site disposal meeting local, State, and Federal regulations.
- Review the process trains with SOCWA staff with respect to potential facility locations, site impacts, and proven performance.
- Prepare estimated project and annual operations and maintenance costs. Operations and maintenance costs shall include labor, maintenance, power, chemicals, and ultimate disposal.
- Perform a life cycle cost analysis. The analysis shall include the net solids handling cost savings at the RTP. The net cost savings consider the loss of digester gas production at the RTP and impact on the existing RTP cogeneration system.

3.0 POTENTIAL PROCESSES

The selected on-site process must be capable of stabilizing the sludge to meet all local, state, and federal requirements for off-site disposal or beneficial use. As a reference point, the other three SOCWA treatment plants (RTP, Plant 3A, and the J.B. Latham Treatment Plant) have anaerobic digesters to stabilize the sludge. The digested sludge is dewatered to approximately 25 percent solids with high-speed centrifuges. The dewatered cake is then hauled off site for disposal or further treatment and beneficial use. The RTP also has elevated cake storage. This allows plant personnel to operate the centrifuges even if a sludge hauling truck is not available. This greatly increases operational flexibility.

3.1 Alternative SH1 – Match Existing Processes

The first alternative recommended for evaluation is Alternative SH1. It consists of the above processes with elevated cake storage. This is recommended for evaluation for the following reasons:

- Operations staff is familiar with the processes and equipment.
- The processes are proven and reliable.
- Anaerobic digestion produces methane gas that can be beneficially used.
- There is space north of the existing Headworks to construct the digester, dewatering, and storage facilities.

The analysis will consider conventional mesophilic anaerobic digestion. Anaerobic digestion can produce Class B biosolids. There are other processes that are capable of producing a Class A biosolid such as thermophilic or phased-digestion. These process variations could be considered at the pre-design level. Class A biosolids are not required at this time with respect to current SOCWA disposal and beneficial use options.

3.2 Alternative SH2 – Biosolids Strategic Plan Alternatives

As discussed above, the second alternative must be capable of stabilizing the sludge for off-site disposal or beneficial use.

The SOCWA Biosolids Management Strategic Plant (2005) also identifies alternatives that can be considered. The purpose of the strategic plan was to identify processes capable of producing Class A biosolids. Not all of the SOCWA plants produce even Class B biosolids at this time. There are more disposal options available for Class A as compared to Class B. However, these processes could also be an alternative to anaerobic digestion. The options considered are given in the following table.

Table 1 Biosolids Management Options
Coastal Treatment Plant Sludge Export System Replacement
South Orange County Wastewater Authority

Treatment	Potential Alternative	Applicability at CTP
Composting	Yes	Enclosed reactor composting is a possibility for raw primary and thickened waste activated sludge (TWAS). The product could produce Class A Biosolids with the potential to be used within the community. This alternative would require delivery of bulking agent and storage and trucking of product.
Pasteurization	No	This process only applies to digested sludge.
Heat Drying/ Pelletization	No	This process only applies to digested sludge. Significant odor concerns and drying problems for raw sludge. The pellets would have to be landfill disposed.
Chemical	Yes	May have applicability. Only very limited chemical treatment being used in California.
Vermiculture	No	Insufficient land area. Odor concerns.
Pyrolosis/ Gasification	Yes	Several potential variations are being developed
Slurry Carb Drying	Yes	This thermal treatment and drying process, proprietary to EnerTech, has had startup problems, but appears close to operation in Rialto.
Incineration	Yes	The facility could cause visual impacts. Expected structure height is approximately 50 feet. The stack may extend beyond this due to the location of the CTP within a valley. Air permitting is expected to be difficult. No incinerators are operating in the South Coast Air Quality Management District. Concerns include New Source Review, toxics, and negative regulatory posture.
Glassification	No	Not a proven process.

The following further discusses the five applicable alternatives identified in Table 1.

3.2.1 Composting

Composting can be done out-of-doors in static or aerated piles or in enclosed reactors. Due to limited space and potential odors, only the enclosed processes should be considered.

The only type of enclosed process used at this time consists of horizontal, open reactors. These aerated reactors are located in-doors for odor control. The only operating facility in California is at the Las Virgines Municipal Water District's (LVMWD) treatment plant. This facility composts anaerobically digested sludge as compared to the raw sludge that would make up this alternative. In past conversations with staff, the facility is very costly to operate. The environment in the composting building is a safety concern (ammonia, H2S, other odors, etc). It has been very difficult for LVMWD to obtain a market for compost. Most is given away at no cost.

A bulking agent such as sawdust, wood chips, or garden wastes must be processed and hauled to the treatment plant to add to the sludge. A greater volume must be trucked from the site for re-use.

The available space may be insufficient for the process building, bulking agent handling and storage, and composted sludge storage.

3.2.2 Chemical Treatment

The most common chemical treatment is lime stabilization. The stabilized sludge can be used as a soil amendment. The sludge has an alkaline pH (greater than 7). Chemically treated sludge is good for amending acidic soils, mostly found on the east coast. The local soils are commonly alkaline, and the addition of the chemically treated sludge would have a negative impact. The chemical treatment process can be very odorous. Chemical treatment requires trucking the chemical to the CTP and trucking a greater volume off-site for disposal. Chemical treatment is not recommended.

3.2.3 Pyrolysis/Gasification

One option that is receiving a lot of interest today is gasification, mainly because the process reduces sludge volumes to levels similar to incineration without the emissions or tall stack concerns. In addition, gasification vendors claim gasification provides more opportunity to be net neutral energy systems, and in some cases, net positive energy producers. However, these promising gasification processes are on the cutting edge with little or no full size operational experience on biosolids.

Three companies actively pursuing gasification projects in the municipal wastewater industry include Maxwest, Nexterra, and M2Renewables. Maxwest and Nexterra require minimum solids loading of 20 dry tons per day or higher to be cost effective. This is much higher solids loading that what is produced at the CTP, so these manufacturers were not considered further. M2Renewables offers a gasification system with a minimum solids loading of five dry tons per day, which is about the amount available from the plant. This technology was considered for this evaluation. They also claim that net positive energy can be produced at this loading. M2Renewables offers the option to purchase their gasification system or a design-build-own-operate delivery.

3.2.4 <u>Slurry Carb Drying</u>

EnerTech has developed a unique process and constructed a 700 wet ton per day facility in Rialto. This process uses heat treatment using methane generated from an anaerobic treatment of the water from the sludge it is dewatering to fuel a heat treatment process and dryer. There have been numerous startup problems with this facility, but EnerTech indicates it is close to full-scale operation.

3.2.5 <u>Incineration</u>

Incineration would pose several problems. The facility could be at least 50 feet in height. Because of the surrounding topography, the stack may have to extend well above the top of the building. Visual impacts would be a concern. Permitting would be very difficult due to negative attitude by South Coast Air Quality Management District (SCAQMD) staff towards this process. Toxics and New Source Review add to the difficulties.

3.3 Alternative SH2 – Emerging Technologies

Two newer, emerging technologies have been considered for the second alternative. One is the Cannibal process. The advantage of this process is the very low level of solids production. However, this process has only been used to process waste activated sludge. The applicability of treating raw primary sludge was reviewed with the process’s owner. Their process engineers replied that Cannibal is not applicable for this use. It could only be used if the primary sludge is first aerobically or anaerobically digested. This would add significant costs and space requirements. The Cannibal process is not recommended.

The second type of process is a pre-digestion heat treatment process of which there are two major ones. The leader is the Cambi process, and the Exelys process by Kruger is the second one. The Cambi process uses high temperature and pressure in three-stage-pressure hold and release tanks to solulabilize primary sludge and WAS. This process also provides Class A biosolids at the end of digestion. The major advantage of the process is that it can take in 16 percent solids that break down to 9 percent solids through the Cambi process and come out with a low viscosity that can be mixed in a digester. This allows the digester volume to be reduced by 50 percent. In addition, the solulabilization leads to better solids destruction so that the energy balance has been determined to be equivalent to conventional digestion.

The Exelys process is similar; however, it uses a continuous flow through process and is reported to produce the same results.

On the negative side, high-pressure steam is required – which works well in large systems with large turbine cogeneration. To get to the required feed of 16 percent solids either centrifuges or belt presses are also required for the primary and waste activated sludge.

The Cambi and Exelys processes would require both the digestion and dewatering components that are part of Alternative SH1. This would increase costs. The available site may be too limited for this process, digestion, dewatering, and cake storage. This process is not recommended.

3.4 Recommended Alternative SH2

With respect to the site constraints, applicability, and process, sludge gasification is recommended for Alternative SH2. This will be compared to Alternative SH1 in the subsequent sections. The other processes were eliminated for the reasons listed in Table 2.

Table 2 Eliminated Options
Coastal Treatment Plant Sludge Export System Replacement
South Orange County Wastewater Authority

Option	Reason
Composting	Space, added trucking, unknown market for product.
Chemical	Not applicable for local soil amendment.
Incineration	Visual impacts, difficult to permit.
Cannibal	Not applicable for raw sludge.
Cambi & Exelys	No cost advantage.

4.0 SLUDGE CHARACTERISTICS

The important sludge characteristics include total solids, volatile solids, and volume. The volume depends on the total solids content of the raw primary sludge and the thickened WAS.

4.1 Existing Characteristics

For Alternatives FM1 and FM2, the sludge is diluted to prevent excessive pumping pressures. The pumped solids content ranges from approximately 1 to 2 percent. The current solids contents as developed as part of the PDR are reported in Table 3.

Table 3	Existing Sludge Flows and Characteristics Coastal Treatment Plant Sludge Export System Replacement South Orange County Wastewater Authority		
Parameter	**Unit**	**Average Day**	**Maximum Month**
Primary Sludge(1)			
Flow	gpd	61,016	66,000
Sludge Production	lb/d	7,072	10,205
Percent Total Solids	%	1.40	2.01
Percent Volatile Solids	%	88.6	85.2
Thickened Waste Activated Sludge(2)			
Flow	gpd	25,844	41,000
Sludge Production	lb/d	3,491	4,245
Percent Total Solids	%	1.80	2.76
Percent Volatile Solids	%	83.3	85.5

Notes:
(1) Calculated from the influent TSS and assuming a 67.4% removal in the primary clarifiers.
(2) Calculated from WAS flow and WAS concentrations assuming 95% capture rate in the DAF thickener.

4.2 Thickened Sludge Characteristics

Alternatives SH1 and SH2 need a more concentrated sludge with a higher solids content and lower volume. While the existing sludge is diluted, the existing primary clarifiers and dissolved air flotation (DAF) thickeners are capable of producing much thicker sludge applicable to this evaluation. Sludge thickening is discussed in detail in the PDR.

The range of potential sludge concentrations are reported in Table 4. As discussed in the PDR, the East primary clarifiers are shallower and have a smaller sludge hopper as compared to the West units. The achievable thickened solids concentration is somewhat lower.

Table 4	Probable Sludge Concentrations (Percent) Coastal Treatment Plant Sludge Export System Replacement South Orange County Wastewater Authority		
West Primary	**East Primary**	**Thickened WAS(1)**	**Combined**
4-5	3-4	4-5	3.3-5.0

Notes:
(1) WAS – Waste Activated Sludge

4.3 Design Characteristics

Table 5 presents the design characteristics used in this evaluation. They have been developed based on the information presented in Tables 3 and 4.

Table 5	Design Characteristics Coastal Treatment Plant Sludge Export System Replacement South Orange County Wastewater Authority		
Parameter	**Unit**	**Average Day**	**Maximum Month**
Flow	gpd	30,157	41,253
Sludge Production	dry lb/d	10,564	14,450
Percent Total Solids	%	4.2	4.2
Volatile Solids	lb/d	9,174	12,324

5.0 ALTERNATIVE SH1

This section presents the development of Alternative SH1. This alternative consists of existing in-basin primary sludge thickening, existing DAF thickening of the WAS, anaerobic digestion, centrifuge dewatering, and elevated cake storage. Cogeneration is included to provide beneficial use of the digester gas.

5.1 Digestion Design Criteria

The important digestion design criteria include detention time and volatile solids loading. The recommended criteria have been previously developed as part of Carollo Engineers Digester Capacity Evaluation Report for the J. B. Latham Treatment Plant in June 2010. These criteria are applicable to all of the SOCWA plants. The criteria are summarized in Table 6. Criteria are listed for the five digestion goals as identified by SOCWA staff.

Table 6	Digestion Goals and Suggested Criteria [(1)] Coastal Treatment Plant Sludge Export System Replacement South Orange County Wastewater Authority				
Criteria/Goal	**Odor Control**	**Operational Stability**	**Class B Reg. Compliance**	**Increased Solids Destruction**	**Increased Gas Production**
Hydraulic Retention Time	12 day min. 15 day ave.	12 day min. 15 day ave.	15 day min. 20 day ave.	15 day min. 20 day ave.	15 day min. 20 day ave.
Volatile Solids Loading	0.20 max. 0.15 ave.	0.20 max. 0.15 ave.	No Criteria	0.15 max. 0.12 ave.	0.15 max. 0.12 ave.
Temperature	95 min. 98 set point	95 min. 98 set point	95 min. 98 set point	95 min. 98 set point	95 min. 98 set point
Notes: (1) Taken from Digester Capacity Evaluation Report, Carollo Engineers, June 2010.					

For this analysis, the digester volume will be based on a minimum hydraulic retention time of 15 days. This will allow disposal or beneficial reuse that requires at least Class B biosolids. While not required now, this would provide future disposal flexibility at a small incremental cost. In addition, two days of liquid storage and two days of cake storage will be considered for operational flexibility and reliability.

5.2 Digestion Sizing

Based on the sludge characteristics and design criteria, the required digester volume is 701,300 gallons. This provides for 15 days of operational volume at the maximum month conditions. It also includes 2 days of liquid storage.

The digester volume could be constructed as one tank or two tanks of equal volume. Two tanks provide additional flexibility but at a higher cost. In addition, the digester goals would not be met when one of the digesters is out of service for cleaning or mechanical/structural rehabilitation. The required volume would need to be increased two-fold to meet the Class B criteria and 165 percent to meet the minimum requirements for odor control or operational stability. Either of these options would add significant costs.

Digester cleaning is required approximately every 5 years. A digester can be cleaned in approximately 60 calendar days. Considering the cost, this analysis will consider that the sludge will be trucked to the RTP during the cleaning period. This is the current backup method and would also be the backup for Alternatives FM1 and FM2.

The digester configuration and loading is given in Table 7.

Table 7 Digestion Configuration and Loading
Coastal Treatment Plant Sludge Export System Replacement
South Orange County Wastewater Authority

Configuration Parameter	Unit	Average Day	Maximum Month
Digester	gpd	30,157	41,253
Number of Units	Each	1	1
Diameter	Feet	69	69
Side Water Depth	Feet	25	25
Volume	Gal	701,300	701,300
Process Loading Parameter			
Sludge Retention Time	Days	20.5	15
Liquid Sludge Storage	Days	2.7	2
Volatile Solids Loading	lb/d/cf	0.111	0.149

The process loading for both detention time and volatile solids are within the recommended criteria in Table 6 for all goals.

5.3 Dewatering

This analysis is based on the use of high-speed centrifuges for dewatering the digested sludge. Centrifuges are used at the other three SOCWA plants and operation and maintenance personnel are familiar with them. Centrifuges are capable of producing a cake with a solids content of approximately 25 percent. This high solids content reduces trucking costs as compared to other dewatering equipment such as belt filter presses.

The centrifuge sizing is based on 8 hours of operation five days a week. For the maximum month, the average flow is 120 gallons per minute. Centrifuges are available in this capacity. Two centrifuges would be installed for mechanical redundancy. Other equipment includes sludge feed pumps, one per centrifuge, polymer storage and blending equipment, and sludge cake pumps.

5.4 Cake Storage

The dewatered sludge would be pumped to elevated cake storage. The sludge trucks would drive below the elevated hopper for loading. The enclosed loading facility would be equipped with a truck scale to prevent over-weight loads.

Two days of sludge cake storage would be provided. This converts to approximately 5 cubic yards.

5.5 Odor Control

The dewatering facility, including the truck loading bay, would be enclosed in a building for odor control. An odor scrubber would be installed to treat the foul air.

5.6 Sludge Equalization Basin

As discussed in section 5.2, the digester would be out of service for 60 days every five years for cleaning. The sludge would be trucked to the RTP for digestion and dewatering. This will require construction of the planned Sludge Equalization Basin. The primary sludge and WAS would be pumped to this basin for storage between truck loads, during the night, and on weekends. Without the basin, the solids build up in the process resulting in potential violation of discharge standards and disruption of recycled water production.

For this evaluation, the information contained in the 2006 draft report Coastal Treatment Plant Export Sludge Equalization Basin will be used.

The need for the basin is common among all alternatives. Therefore, the costs have not been included.

5.7 Truck Trips

The dewatered cake would be trucked off-site for beneficial use. This is the current practice at the RTP. There would be no net increase in truck trips, but the trips would now originate at the CTP. It is estimated that 4 trips would occur during each 5-day work week. There could be days with no trips and some days with up to two trips.

5.8 Cogeneration

Digester gas can be utilized to provide electricity through a cogeneration facility. Either microturbine technology or engine-generator would be applicable. Fuel cell technology is not available in a capacity that matches digester gas production. The capital costs are nearly equivalent for the available technologies. For this analysis, engine-generators are analyzed, as this technology matches those used at other SOCWA plants.

Digester gas production is estimated at 75,700 cubic feet per day (cfd). Using a conservative digester gas heat value of 550 British thermal units per cubic feet (BTU/cf), the cogeneration facility can provide approximately 132 kilowatts (kW) of energy. The cogeneration system would consist of two 65 kW engine-generators, with gas conditioning equipment. The gas conditioning equipment consists of hydrogen sulfide removal, moisture removal, siloxane removal, and a particle filter to provide the gas quality suitable for use in the engine-generator. Heat recovery on the exhaust will provide hot water heating for use in digester heating. The engine-generator will require treatment of the exhaust to reduce emissions to allowable levels. The treatment includes a selective catalytic reducer to remove nitrogen and carbon monoxide. A boiler and waste gas flare will still be required for times when the cogeneration facility is under maintenance. The cogeneration equipment and associated piping, and part of the gas conditioning system would be installed in a building. Gas conditioning tanks would be installed outside for ease of access.

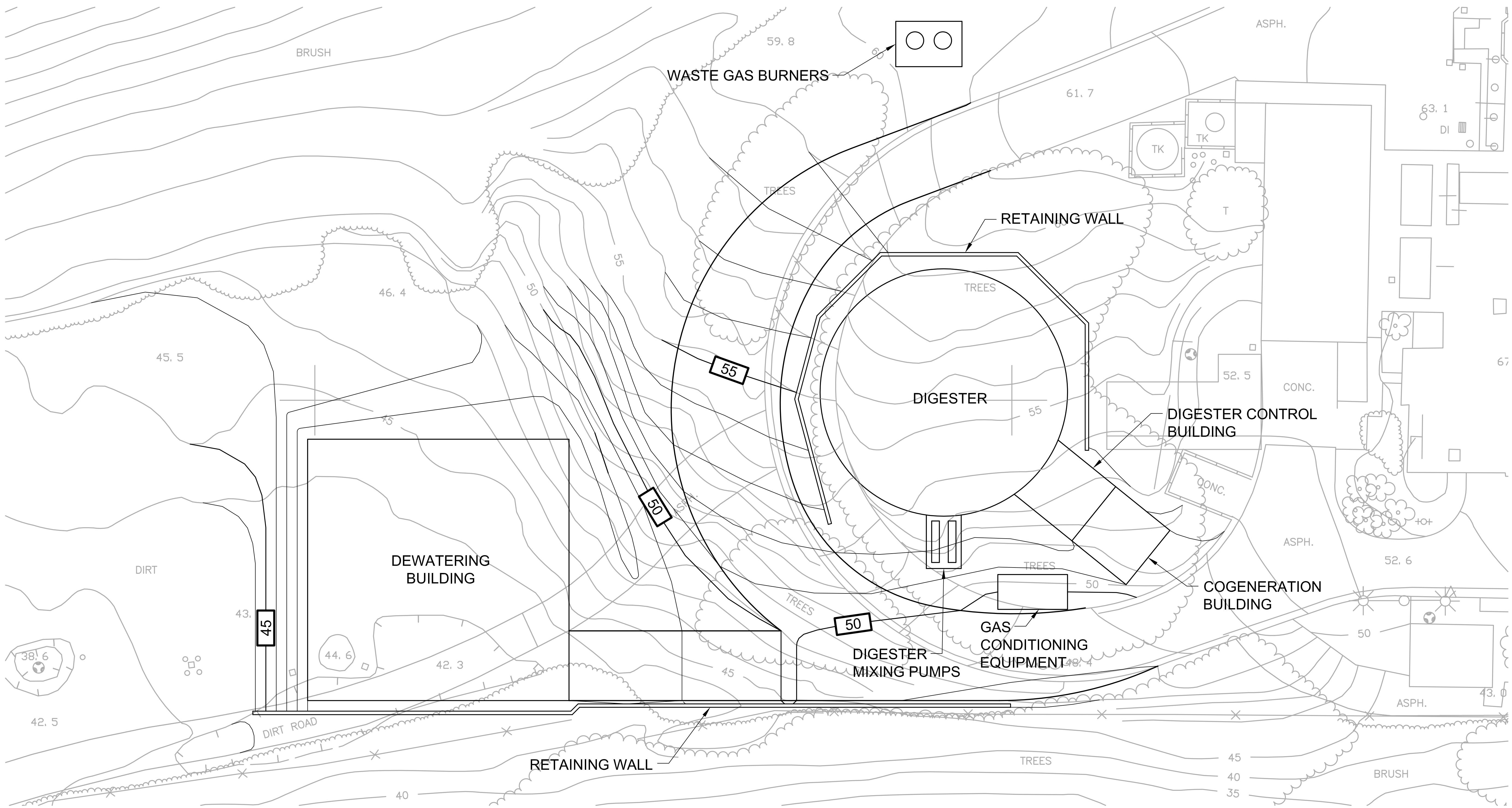
5.9 Site Layout

A potential site layout is shown on Figure 1. The digester can be constructed in the area just north of the Headworks. The Dewatering Building would be constructed just north of that. The Dewatering Building would also house the digester boiler, heat exchanger, recirculation pumps, and hot water pumps. All of the new electrical equipment would also be in this building.

Based on the existing topography, part of the Dewatering Building would have to be constructed on an engineered fill. The entire area may require over-excavation and re-compaction. This would be confirmed by a geotechnical evaluation as part of the final design.

The sludge trucks would have to back through a curved drive into the loading facility. While this is not ideal, other plants have this same situation with minimal problems.

The Sludge Equalization Basin would be placed north of the Dewatering Building. This is not the ideal location for truck access, but this event occurs only 2 months, every five years. Shortage of available space is a drawback for this alternative.



GRAPHIC SCALE

0 15' 30' 60'

SCALE: 1" = 30'

KEYMAP

SCALE: 1"=30'

FIGURE 1

Solids Handling Alternative SH1

Site Plan

carollo

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5.10 Building Height

The tallest structure would be the dewatering building. The top of the building is estimated to be at elevation 90. The highest point of the nearby Screenings Building is elevation 87.5. Therefore, there would not be a significant new visual impact.

5.11 Estimated Costs

This section presents estimated capital costs, operations and maintenance (O&M) costs, and equivalent annual cost.

5.11.1 Capital Costs

Capital costs for the Digester, Dewatering Building and Cogeneration Building have been estimated based on completed projects by Carollo Engineers and quantity take-offs where applicable. The capital cost for the cogeneration system can be offset by available grant funds through the Self Generation Incentives Program (SGIP) offered by the local utility, Pacific Gas & Electric. The available grant will not cover the full cost of the cogeneration system. A contingency of 30 percent is included as well as 20 percent for project costs. Project costs include engineering, construction management, legal and administrative costs. Capital costs for Alternative SH1 are provided in Table 8.

Table 8 Alternative SH1 Capital Costs
Coastal Treatment Plant Sludge Export System Replacement
South Orange County Wastewater Authority

Cost Item	Quantity	Unit	Cost
Digester	1	Lump Sum	$3,370,000
Dewatering Building	1	Lump Sum	$4,714,000
Cogeneration Building	1	Lump Sum	$1,314,000
Estimating Contingency	30	Percent	$2,819,000
Project Cost Contingency	20	Percent	$2,443,000
		Estimated Project Cost	$14,660,000
		SGIP Grant Fund	($330,000)
		Total Project Cost	$14,330,000

5.11.2 Operations and Maintenance Costs

Operations and maintenance cost include labor, maintenance, electrical power, chemicals, and sludge disposal. The estimated costs are presented in Table 9. If implemented, the gas production at the RTP would be decreased. The energy production lost at RTP would be equivalent to the energy savings at CTP with the new cogeneration system. A credit has applied for the export sludge pumping power requirements. The pumping system would no longer be needed, resulting in an estimated annual power savings of $18,000.

Table 9 Alternative SH1 O&M Costs
Coastal Treatment Plant Sludge Export System Replacement
South Orange County Wastewater Authority

Cost Item	Annual Quantity	Unit Cost	Annual Cost
Labor	1,700 Hours	$35	$59,500
Electrical Power	503,000 kWhrs	$0.09	$45,000
Ferric Chloride	9,000 Gallons	$0.31	$34,000
Sodium Hypochlorite	29,000 Pounds	$1.00	$29,000
Sodium Hydroxide	9,000 Gallons	$3.00	$27,000
Polymer	75,000 Pounds	$1.10	$83,000
Cake Disposal/Use	3,625 Dry Tons	$75	$272,000
Cogeneration	196,400 kWhrs	$0.035	$40,000
Maintenance[1]	--	--	$143,000
Average Annual Trucking Cost[2]	N/A	N/A	$10,000
Export Sludge Pumping Savings	196,400 kWhrs	$0.09	($18,000)
		Annual Cost	$724,500

Notes:
(1) Based on 1 percent of Capital Cost
(2) Average annual cost over the five years between digester cleaning.

5.11.3 Equivalent Annual Cost

The equivalent annual cost considers both capital and O&M costs. The equivalent annual cost is useful in comparing alternatives. The equivalent annual cost has been calculated based on the following factors:

1. Interest Rate – 6 percent
2. Evaluation Period – 20 years
3. Structural Life – 50 years
4. Mechanical Life – 20 years
5. Depreciation – straight line.

The equivalent annual cost for Alternative SH1 is $1,805,000. The annual cost is $936 per dry ton of raw sludge generated at the plant.

6.0 ALTERNATIVE SH2

The gasification process involves applying a controlled amount of air to supply a small amount of oxygen to control the heat of a fuel rich sludge, temperature-controlled environment (greater than 800 degrees Celsius). Most of the volatile portion of the sludge is converted into synthesis gas, also called "syngas." However, complete combustion is not realized in the gasifier because gasification operates in an oxygen-starved environment. An estimated 80 percent of the solids are converted to syngas. The remaining ash has little value and is usually disposed of similar to incinerator ash. Though there are ongoing studies evaluating its use as a fertilizer, this analysis considers the ash will be disposed of in a landfill.

Dewatered sludge is fed into a dryer to reduce the moisture content to approximately 10 to 20 percent. Dried solids are then conveyed into the gasifier where the majority of the volatile content of the solids are converted to syngas. The feed rate of the dried solids is controlled to optimize syngas production. The syngas is quenched, cleaned, and dried before being used in engine-generators to produce electricity. Flue gas from the engine-generators is treated before they are discharged to atmosphere. Waste heat from engine-generators is used to heat the solids dryer, however supplemental natural gas is required to complete the drying process. Flue gas from the solids dryer is conveyed to an odor control system prior to atmospheric discharge.

The CTP is staffed 5 days per week, 8 hours per day, and a minimal crew on the weekend, which is not ideal for thermal conversion facilities. Gasification systems should be operated for long durations to be cost effective. For the purposes of this study, the gasification system was evaluated to operate 330 days per year, 24 hours per day.

6.1 Gasification Design Criteria

Table 10 summarizes the basis of design for the gasification system evaluation.

Table 10 Gasification Basis of Design
Coastal Treatment Plant Sludge Export System Replacement
South Orange County Wastewater Authority

Parameter	Unit	Value
Basis of Design		
Parameter	Unit	Value
Operating days	Days per year	330
Operating hours	Hours per day	24

Table 10 Gasification Basis of Design
Coastal Treatment Plant Sludge Export System Replacement
South Orange County Wastewater Authority

Parameter	Unit	Value
Sludge flow	Gallons per day	30,157
	Percent solids	4.2
	Pounds per day	10,564
Screw Press		
Cake production	Pounds per day	10,036
	Percent solids	25
Polymer demand	Pounds per day (active)	185
Washwater demand	Gallons per day	4,800
Filtrate	Gallons per day	25,344
Dryer		
Dried solids production	Pounds per day	9,935
	Percent solids	77
Water evaporated	Gallons per day	3,266
Scrubber water demand	Gallons per day	100
Natural gas demand	Million BTUs per day	17.8
Gasification		
Ash production	Pounds per day	1,870
Scrubber water demand	Gallons per day	3,600
Ash blowdown water demand	Gallons per day	960

Table 10 Gasification Basis of Design Coastal Treatment Plant Sludge Export System Replacement South Orange County Wastewater Authority		
Parameter	**Unit**	**Value**
Electricity Production		
Gross power output	Kilo Watts	400
System parasitic load	Kilo Watts	162
Net power output	Kilo Watts	238

6.2 Site Layout

The proposed gasification facility includes a dewatering screw press, sludge dryer, dried solids storage, gasification system, air pollution and odor control systems, ash storage and loading, engine generator, and the control room. The facility would be housed in a building approximately 55-ft x 75-ft, which would be located in the area north of the access road near the Screenings Building as shown on Figure 2. The building is located in the same location as the dewatering building in Alternative SH1.

6.3 Building Height

The height of the building is expected to be between 20 to 25 feet with a stack penetrating ten feet above the roof.

The elevation of the top of the building is estimated to be elevation 75. The elevation of the stack would be about elevation 85. These compare to the top of the Screenings Building at elevation 87.5. There would no significant change in the visual impact.

6.4 Truck Trips

Gasification reduces solids to an ash. The proposed system is expected to produce approximately 309 tons of ash per year. This would require about 16 trips per year for ash disposal, assuming each truck has a 20-ton capacity.

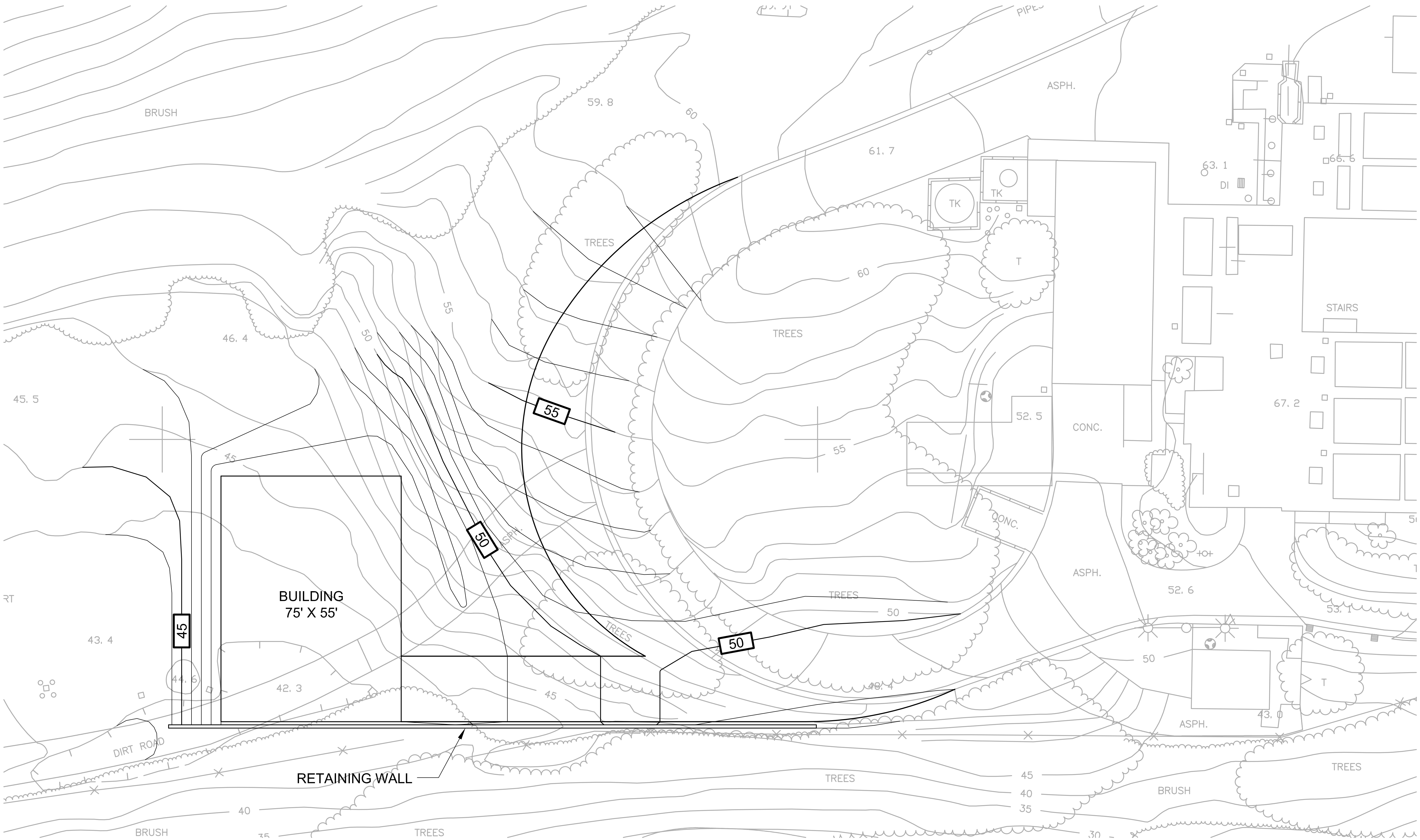

FIGURE 2

Solids Handling Alternative SH2

Gassification Building Site Plan

GRAPHIC SCALE

0 15' 30' 60'

SCALE: 1" = 30'

KEYMAP

SCALE: 1"=30'

carollo

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South Orange County Wastewater Authority

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6.5 Estimated Costs

This section presents estimated capital costs, operations and maintenance (O&M) costs, and equivalent annual cost.

6.5.1 Capital Costs

Capital costs for the gasification facility have been based on the manufacturer's budget quotation. A contingency of 30 percent is included as well as 20 percent for project costs. Project costs include engineering, construction management, legal and administrative costs. Capital costs for Alternative SH2 are presented in Table 11.

Table 11 Alternative SH2 Capital Costs
Coastal Treatment Plant Sludge Export System Replacement
South Orange County Wastewater Authority

Cost Item	Quantity	Unit	Cost
Gasification System	1	Lump Sum	$7,787,000
Building	1	Lump Sum	$1,238,000
HVAC	3	Percent[1]	$271,000
Mechanical Piping	5	Percent[1]	$451,000
Electrical and Instrumentation	15	Percent[1]	$1,354,000
Estimating Contingency	30	Percent[2]	$3,330,000
Project Cost Contingency	20	Percent[3]	$2,886,000
		Total Project Cost	$17,317,000

Notes:
(1) Percentage based on the sum of the gasification system and the building.
(2) Percentage based on the sum of the gasification system, building, HVAC, mechanical piping, and electrical and instrumentation.
(3) Percentage based on the sum of the gasification system, building, HVAC, mechanical piping, electrical and instrumentation, and estimating contingency.

6.5.2 Operation and Maintenance Costs

Operations and maintenance cost include labor, maintenance, natural gas, avoided electrical power, chemicals, and ash hauling and disposal. The estimated O&M cost are presented in Table 12.

Table 12	Alternative SH2 Operations and Maintenance Costs Coastal Treatment Plant Sludge Export System Replacement South Orange County Wastewater Authority		
Cost Item	**Annual Quantity**	**Unit Cost**	**Annual Cost**
Labor	1,980 Hours	$35	$69,000
Natural Gas	59,000 Therms	$1	$59,000
Maintenance[1]	Lump Sum	$75,000	$75,000
Consumables (chemicals, filters)	Lump Sum	$45,000	$45,000
Polymer	61,000 lbs/yr	$1.10	$67,000
Engine Generator Maintenance	Lump Sum	$58,000	$58,000
Ash hauling and disposal	309 tons/year	$40	$12,000
Dried solids hauling and disposal[2]	205 tons/year	$40	$8,000
Avoided Electrical Power	1,885,000 kWhrs	$0.09	($170,000)
Export Sludge Pumping Savings	196,400 kWhrs	$0.09	($18,000)
		Annual Cost	$205,000

Notes:
(1) Based on input from M2Renewables.
(2) Dried solids would be produced and disposed during system downtime, which is expected to be 35 days per year.

6.5.3 Equivalent Annual Cost

The equivalent annual cost considers both capital and operations and maintenance costs. The equivalent annual cost is useful in comparing alternatives. The equivalent annual cost has been calculated based on the following factors:

1. Interest Rate – 6 percent
2. Evaluation Period – 20 years
3. Structural Life – 50 years
4. Mechanical Life – 20 years
5. Depreciation – straight line.

The equivalent annual cost for Alternative SH2 is $1,510,000. The annual cost is $783 per dry ton of raw sludge generated at the plant.

6.5.4 Design-Build-Own-Operate Costs

M2Renewables offers both an equipment purchase option as detailed in the previous sections and a design-build-own-operate delivery. M2Renewables would finance the construction of the gasification facility described above. They would provide services to gasify sludge from the CTP and dispose of residual ash for a service fee. The fee would be based on a guaranteed sludge flow and characteristics. In addition, the CTP could purchase electricity generated from the gasification facility to supplement plant usage. Table 13 summarizes the annual costs for this service.

Table 13 Alternative SH2 DBOO Cost Summary
Coastal Treatment Plant Sludge Export System Replacement
South Orange County Wastewater Authority

Cost Item	Annual Quantity	Unit Cost	Annual Cost
Gasification Service Fee	Lump Sum	$480-$640/dry ton	$925,000-$1,234,000
Electrical Power Offset	1,885,000 kWhrs	$0.015	$28,000
		Annual Cost	$897,000-$1,206,000
		Cost per Dry Ton of generated raw sludge	$465-$626

7.0 ALTERNATIVE COMPARISON

This section compares the two SH alternatives with respect to cost and other intangible factors.

7.1 Cost

The costs for the two alternatives are compared in Table 14. Alternative SH2 has a much higher project cost but lower annual operations and maintenance cost. This is due to lower disposal/use costs and the electrical power offset. With the lower operations and maintenance costs, the equivalent annual costs are essentially the same. Alternatively, if the agency chose to implement privatized gasification services, the annual cost is estimated to be $465-$626 per dry ton of raw sludge.

Table 14 Alternative Cost Comparison
Coastal Treatment Plant Sludge Export System Replacement
South Orange County Wastewater Authority

Cost	Alternative SH1	Alternative SH2
Total Project Cost	$14,330,000	$17,317,000
Annual O&M Cost	$620,500	$205,000
Equivalent Annual Cost	$1,805,000	$1,510,000
Cost per Dry Ton	$936	$783

7.2 Proven Technology

Alternative SH1 consists of proven technologies that are very familiar to SOCWA operations and maintenance staff. Alternative SH2 is a new technology. The facilities would require special training of staff. There is a higher risk in implementing Alternative SH2.

7.3 Site Impacts

Both alternatives could fit within the available land and would require construction in the area north of the circular road. The hauling trucks would have to back into the Dewatering or Ash Loading Building to load solid residuals. However, SH1 requires additional space for a Sludge Equalization Basin, which is not required for SH2. The available space for this building would result in awkward access for the tanker trucks. However, this only occurs for two months every five years.

7.4 Implementation

Alternative SH1 can be implemented by a traditional design, bid, and construct approach. This approach provides competitive bidding with multiple manufactures of all equipment.

There is only one available supplier for Alternative SH2. This makes a traditional delivery method problematic with respect to competitive pricing. The Authority would need to pre-negotiate a price. The other option would be to use a design-build-own-operate approach as discussed above. This may have advantages with respect to risk, ongoing operation and maintenance and cost. This would be the preferred implementation method. A fair price would still need to be negotiated.

7.5 Permitting

Permitting for Alternative SH1 is fairly straightforward. The major permit would be from the South Coast Air Quality Management District (SCAQMD). However, there would be essentially no increase in emissions. The emissions at the RTP would be decreased once the new facilities are constructed.

The SCAQMD permit for Alternative SH2 may be harder to procure. However, there are examples of thermal sludge processes being permitted (EnerTech).

8.0 SUMMARY

Alternative SH1 is the appropriate alternative for environmental comparison. This alternative consists of existing in-basin primary sludge thickening, DAF thickening of the WAS, anaerobic digestion, centrifuge dewatering, and elevated cake storage. These are conventional processes familiar to the CTP staff. Additionally, this alternative can be constructed with traditional project delivery options and the permitting process is fairly straightforward.

Alternative SH2 has an estimated higher capital. The gasification process is a much newer technology and it would require special staff training. There is only one company that would be interested in a facility of this smaller size. Permitting would be more difficult. There are more unknowns concerning cost and implementation.

Perhaps the DBOO option for gasification could be considered. This option may offer a significantly lower cost per dry ton. However, the data used to generate this estimate was very limited. Sending samples to M2 Renewables to refine their design criteria and budget estimate is required to determine a more accurate estimated cost for this option.