SOUTH ORANGE COUNTY WASTEWATER AUTHORITY

COASTAL TREATMENT PLANT
SLUDGE EXPORT REPLACEMENT PROJECT

GREENHOUSE GAS PROJECTIONS

FINAL
September 2012

SOUTH ORANGE COUNTY WASTEWATER AUTHORITY

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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). The primary sludge and thickened waste activated sludge (TWAS) 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 diameter force mains. Only one is needed at a time, the second serves as a backup. The 4.5-mile long force mains are approximately 30 years old and are approaching the end of their useful life. Replacement with new force mains or an alternative sludge handling method is required.

SOCWA has been evaluating a wide range of alternatives to replace the force mains. The Export Sludge Force main Pre-Design Report (PDR) identified 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, connecting to the existing Phase II 6-inch diameter sludge line in Aliso Viejo Community Association Road.
- Alternative TR1: Haul liquid sludge from the CTP to the RTP by trucks along existing roads and streets.

Carollo Engineers (Carollo) has submitted a draft report that identifies a fourth viable alternative. The draft report On-Site Sludge Replacement Analysis recommended that Alternative SH1 be considered. This alternative consists of on-site anaerobic digestion, dewatering, cogeneration, and beneficial use of the biosolids. It would eliminate transportation to the RTP. A second on-site alternative was considered. It would consist of thermal treatment. The technology is very new and not proven in the U.S. For this reason, it is not considered in this report.

Finally, SOCWA staff will evaluate a fifth alternative, Eliminate Coastal Treatment Plant (ECTP). There are several sub-alternatives to this last one. These alternatives will be compared with respect to environmental and other issues before a final alternative is selected for implementation.

2.0 PURPOSE AND SCOPE

In addition to the technical documents, an Environmental Impact Report (EIR) will be prepared to compare the impacts of each alternative. One element used for comparison is the contribution of greenhouse gas (GHG) emissions. The Scope of Work for this technical memorandum (TM) is to estimate the GHG contributions for each alternative being considered.

The GHG estimates are for the ongoing operations and maintenance of the facilities. The elements include power, chemicals, and diesel fuel. For each alternative, the solids disposal method is identical. The biosolids are disposed of off-site for beneficial use (i.e., there is no significant net difference between the alternatives). For the force main (FM1 and FM2), trucking (TR1), and ECTP alternatives, the sludge would be handled at the RTP or the J.B. Latham Wastewater Treatment Plant (JBLTP), while for the SH1 alternative the sludge will be handled on-site. The solids will be anaerobically digested, and the digester gas will be used to fuel cogeneration facilities.

The following describes the tasks that were performed.

2.1 Scope of Work

The specific items of work are:

- Summarize the estimated electrical power consumption of each alternative, taking into consideration the relative changes in RTP digester gas production and cogeneration power production.
- Summarize the estimated on-going chemical consumption.
- Summarize the estimated on-going fuel consumption for Alternative TR1. This is the only alternative that consumes diesel fuel for daily transport of solids from CTP to the RTP.
- Estimate the GHG production.
- Prepare a TM summarizing the work.
- Meet with SOCWA staff.

2.2 Methodology

The GHG emissions have been estimated using a set of measuring standards and protocols aligned with the international GHG Protocol Initiative – The Climate Registry

General Reporting Protocol (TCR GRP) and the Local Government Operations Protocol (LGOP).

Not all GHGs are relevant to the water and wastewater industry – only carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are relevant and comprise the majority of GHG emissions generated from the conveyance and treatment of water and wastewater. The development of GHG emissions estimates requires a set of boundary conditions to define the life cycle stages, the unit processes, and the timeframe that is included in the analysis. For this analysis, SOCWA's estimated annual GHG emissions are a result of the ongoing operations and maintenance phases of the alternatives, including power, chemicals, and fuel consumption.

The GHG emissions included in the analysis are categorized as direct or indirect:

Direct GHG emissions result from sources that are owned or controlled by an agency, such as stationary combustion units, mobile combustion, and treatment unit processes. For this inventory, this includes fuel combustion, as well as the combustion of digester gas in a cogeneration system.

Indirect GHG emissions are those originating from the actions of the agency, but are produced by sources owned or controlled by another entity. For this inventory, this includes purchased electricity for the operation of facilities in each alternative, the energy and fuel consumption for the production and transport of chemicals, the production of diesel fuel, as well as the transport of solids to their beneficial use/disposal location.

To meet the definitions established by the above-mentioned protocols (i.e., TCR GRP and LGOP), the GHG emissions are further categorized into three broad scopes:

- Scope 1 emissions include all direct GHG emissions.
- Scope 2 emissions are indirect GHG emissions from consumption of purchased electricity, heat, or steam.
- Scope 3 emissions are all other indirect emissions, such as the processing of purchased materials, transport-related activities in vehicles not owned or controlled by the agency, electricity-related activities not covered in Scope 2 (e.g., transmission and distribution losses), outsourced activities, waste disposal, etc.

Once the major sources of GHG emissions are identified and categorized, appropriate emission factors are selected based on the location of the facilities and emissions source. The data is then transferred into Carollo's GHG emissions model to estimate the quantities of CO_2, CH_4, and N_2O emissions generated from each source. Emissions are converted into carbon dioxide equivalent (CO_2e) emissions using the global warming potentials (GWP) of each gas as shown in Table 1.

Table 1	Greenhouse Gases and Global Warming Potentials (GWPs) Coastal Treatment Plant Sludge Export Replacement Project South Orange County Wastewater Authority
Greenhouse Gas	**GWP* (Unit Mass CO_2e/Unit Mass of GHG Emitted)**
Carbon Dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous Oxide (N_2O)	310
* GWPs are from the Intergovernmental Panel on Climate Change Second Assessment Report (1996) for a 100-year time horizon. These GWPs are still used today by international convention and the U.S. to maintain the value of the carbon dioxide "currency," and are used in this inventory to maintain consistency with international practice.	

The major GHG in the atmosphere is CO_2. Other GHGs differ in their ability to absorb heat in the atmosphere. For example, CH_4 has twenty-one times the capacity to absorb heat relative to CO_2 over a hundred-year time horizon, so it is considered to have a GWP of 21. Nitrous Oxide has 310 times the capacity over a hundred-year time horizon having a GWP of 310. Therefore, a pound of emissions of CO_2 is not the same in terms of climatic impact as a pound of CH_4 or N_2O emitted. Carbon dioxide equivalent emissions are calculated by multiplying the amount (mass) of emissions of a particular GHG by its GWP.

3.0 ALTERNATIVE IMPACTS

This section describes the elements that would make up the GHG contributions for the five alternatives.

3.1 Alternatives FM1 and FM2

Alternatives FM1 and FM2 are very similar. They both consist of pumping raw primary and WAS through a force main to the RTP. Two alignments are being compared to replace the existing 4-inch cast iron pipes. At the RTP, the combined sludge is thickened in the dissolved air flotation (DAF) thickeners, anaerobically digested, dewatered, and hauled off site for beneficial use.

In addition to the new force main, a Sludge Equalization Basin would be constructed at the RTP. The basin would serve as the wet well for a new Sludge Export Pump Station and as emergency storage in the case of a pump or force main failure. The sludge would then be trucked to the RTP in an enclosed tanker. This is the current back-up to pumping. For this analysis, the impacts for the tank have been based on the information contained in the draft report Coastal Treatment Plant Export Sludge Equalization Basin, 2006.

The digester gas is used to fuel the existing cogeneration system. It produces electrical energy that meets most of the RTP demands. The GHG produced in the cogeneration system by the contribution from digesting the CTP sludge will be considered.

3.1.1 Electrical Power Consumption

The breakdown of electrical power consumption for alternatives FM1 and FM2 is summarized in Table 2.

Table 2 Alternative FM1 and FM2 Power Consumption
Coastal Treatment Plant Sludge Export Replacement Project
South Orange County Wastewater Authority

Equipment	Comments
Sludge Pumps	Pumping to the RTP. While an existing demand, pumping power must be considered in comparing the alternatives.
Sludge Mixing Pumps	The stored sludge in the Sludge Equalization Basin must be mixed to prevent solids deposition.
Ferric Chloride Pump	A new pump would be constructed to add ferric chloride to the sludge. The purpose is to reduce odors.

The existing odor scrubber would be used. There would be no change in the operation at the RTP. There is no change in future power consumption for these items.

3.1.2 Chemical Consumption

The chemicals that will be added for these alternatives are summarized in Table 3.

Table 3 Alternative FM1 and FM2 Chemical Consumption
Coastal Treatment Plant Sludge Export Replacement Project
South Orange County Wastewater Authority

Chemical	Comments
Ferric Chloride	New chemical use to control odors.
Sodium Hypochlorite	Sodium hypochlorite is used in the existing odor scrubber. This item consists of the amount needed for the added hydrogen sulfide production in the Sludge Equalization Basin. Additional caustic is not required, as caustic only depends on the amount of scrubber make-up water. This will not change.

3.2 Alternative TR1

Alternative TR1 consists of trucking liquid sludge to the RTP. The Sludge Equalization Basin would be constructed. It would include pumps to load the sludge into the enclosed tanker trailers. The sludge pumps would not be constructed. Ferric chloride would not be added, but the additional sodium hypochlorite would still be needed for odor control.

3.2.1 Electrical Power Consumption

The electrical power consumption for alternative TR1 is summarized in Table 4.

Table 4 Alternative TR1 Power Consumption
Coastal Treatment Plant Sludge Export Replacement Project
South Orange County Wastewater Authority

Equipment	Comments
Sludge Mixing Pumps	The stored sludge in the Sludge Equalization Basin must be mixed to prevent solids deposition.
Sludge Loading Pumps	New pumps would be constructed to load the sludge into the enclosed tanker trailer.

As with Alternatives FM1 and FM2, the existing odor scrubber would be used. There would be no change in the operation at the RTP.

3.2.2 Chemical Consumption

The only chemical requiring consideration is the additional sodium hypochlorite that would be used in the existing odor scrubber.

3.2.3 Fuel Consumption

Diesel fuel is consumed by the trucks idling during loading solids, hauling solids, and idling during unloading the solids from the CTP to the RTP. The analysis considers the round-trip hauling (including idling) and an allowance for other mileage, as well as the emissions resulting from the production of diesel fuel.

3.3 Alternative SH1

This alternative consists of anaerobic digestion and dewatering at the CTP. It is the only alternative being considered that would replace the existing impacts at the RTP. Only the added impacts should be considered. For example, Alternative SH1 includes new centrifuges and ancillary equipment for sludge dewatering. Operation at CTP essentially reduces the impact at RTP by the same amount. Therefore, there would be no comparative GHG impact for most of the dewatering facilities.

The digester gas would be used in a on-site cogeneration system.

3.3.1 Electrical Power Consumption

The electrical power consumption for alternative SH1 is summarized in Table 5.

Table 5 Alternative SH1 Power Consumption Coastal Treatment Plant Sludge Export Replacement Project South Orange County Wastewater Authority	
Equipment	**Comments**
Sludge Recirculation Pump	This is in addition to facilities at the RTP.
Hot Water Recirculation Pump	This is in addition to facilities at the RTP.
Sludge Mixing Pump	This is in addition to facilities at the RTP.
Digester Control Building HVAC	A new building would be required in addition to the RTP facilities.
Boiler Burner	This is in addition to facilities at the RTP.
Waste Gas Burner	This is in addition to facilities at the RTP.
Dewatering Building Odor Scrubber	This is in addition to facilities at the RTP.
Dewatering Building Supply Fans	This is in addition to facilities at the RTP.
Centrate Return Pump	This is in addition to facilities at the RTP.
Sludge Equalization Basin Power	Minimal impact—60 days of operation every five years.

This alternative assumes that the same number of operating digesters will be needed at the RTP even with elimination of the CTP sludge. As with Alternatives FM1 and FM2, the existing odor scrubber would be used. Most of the digester gas is combusted in the cogeneration system with the waste gas burner and boiler serving as back-up, however the emissions are nearly the same from each source. There would be no change in the operation at the RTP.

3.3.2 Chemical Consumption

The only chemical requiring consideration is the additional sodium hypochlorite and sodium hydroxide that would be used in the new Dewater Building Odor Scrubber. Ferric chloride would also be added to the digesters or primary sludge to control digester gas hydrogen sulfide levels. However, it is expected that the amount of ferric chloride now added to the RTP digesters can be reduced by a like amount.

3.4 Alternative ECTP

Alternative ECTP would consist of pumping all of the raw wastewater treated at the CTP to either the RTP or JBLTP for treatment. The treatment processes at all three plants are essentially identical. There is no discernible difference in GHG production for liquid treatment and solids handling. The only difference would be the additional pumping energy. This would consist of the difference in pumping elevations and longer pumping distance.

For the alternatives that include JBLTP, the CTP treated wastewater would be discharged through the San Juan Creek Ocean Outfall. It currently is discharged through the Aliso Creek Ocean Outfall. There are four sub-alternatives being considered for ECTP. These are summarized in Table 6.

Table 6 Alternative ECTP Sub-Alternatives
Coastal Treatment Plant Sludge Export Replacement Project
South Orange County Wastewater Authority

Alternative	Description
ECTP1	Eliminate the CTP. Pump raw wastewater to JBLTP.
ECTP2	Eliminate the CTP. Pump raw wastewater to JBLTP. ETM treated wastewater diverted to San Juan Creek Outfall System.
ECTP3	Eliminate the CTP. Pump raw wastewater to RTP.
ECTP4	Eliminate the CTP. Pump raw wastewater to RTP ETM treated wastewater diverted to San Juan Creek Outfall System.

4.0 SUMMARY OF GREENHOUSE GAS EMISSIONS ESTIMATES

This section summarizes the estimates of annual GHG emissions generated per alternative based on the methodology described in Section 2.2. Table 7 and Figure 1 are provided to show the total sources of emissions for alternatives FM1, FM2, TR1, and SH1, as well as the relative contributions to each alternative's annual emissions. The estimates show that the combustion of biogas is a main driver of GHG emissions for each alternative when including the CO_2 emissions and the total annual net emissions are nearly the same.

Carbon dioxide emissions from biogas combustion are considered biogenic (i.e., non-fossil fuel based) and are not counted towards California's cap and trade program. Figure 2 shows the GHG emissions estimates for each alternative *without* the CO_2 emissions from biogas combustion. While alternative SH1 has the largest contribution of GHG emissions, all of the alternatives show negative net GHG emissions due to the generation of electricity onsite (i.e., they offset more GHG emissions than they emit).

In addition, Table 8 and Figure 3 are provided to show the total annual emissions related to purchased electricity for pumping raw wastewater in the ECTP alternatives 1 through 4. The emissions from each of the ECTP alternatives are added to alternative SH1's emissions to result in the total annual emissions. Detailed GHG estimates are provided in the Appendix.

Table 7 Annual Carbon Dioxide Equivalent Emissions for Operation of Each Alternative
Coastal Treatment Plant Sludge Export Replacement Project
South Orange County Wastewater Authority

	Avoided Purchased Electricity	Purchased Electricity	Biogas Combustion	Biogas Combustion (CH_4 & N_2O only)	Diesel Production	Solids Handling	Chemical Production	Chemicals Handling	Total Metric Tons CO_2e	Total Metric Tons CO_2e (no biogenic CO_2)[1]
FM1	-592	77	1,216	6.1	0.3[2]	0	15	3	**719**	**-491**
FM2	-592	78	1,216	6.1	0.3[2]	0	17	3	**722**	**-488**
TR1	-592	30	1,216	6.1	14.5	120	15	2	**805**	**-405**
SH1	-592	128	1,216	6.1	0.2[2]	0	34	2	**788**	**-421**

Notes:
(1) Not including carbon dioxide emissions resulting from the combustion of biogas.
(2) Diesel fuel needed for solids handling and chemical deliveries.

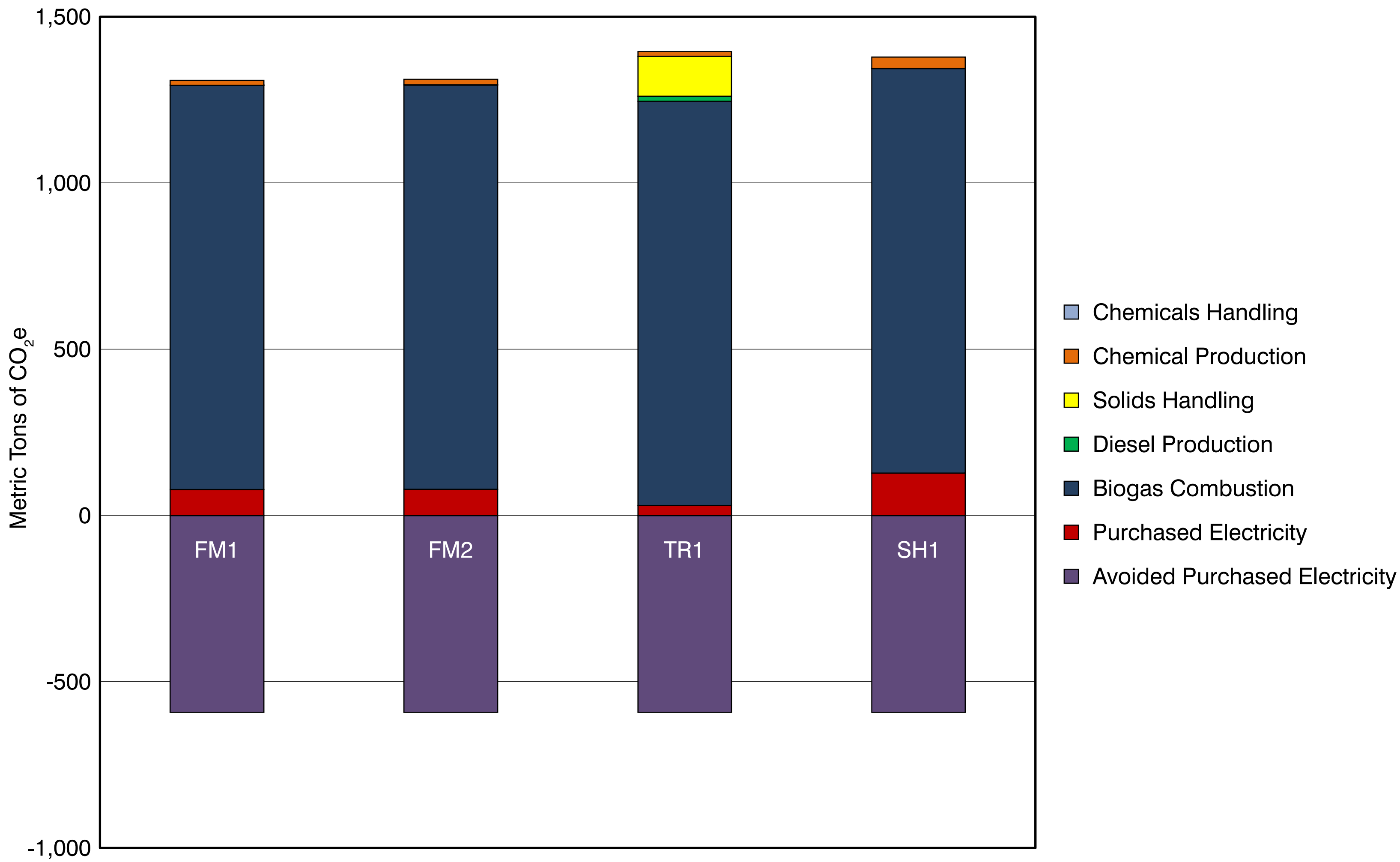

Figure 1
ANNUAL METRIC TONS OF CARBON DIOXIDE EQUIVALENT EMISSIONS DUE TO OPERATIONS
COASTAL TREATMENT PLANT SLUDGE EXPORT SYSTEM REPLACEMENT
SOUTH ORANGE COUNTY WASTEWATER AUTHORITY

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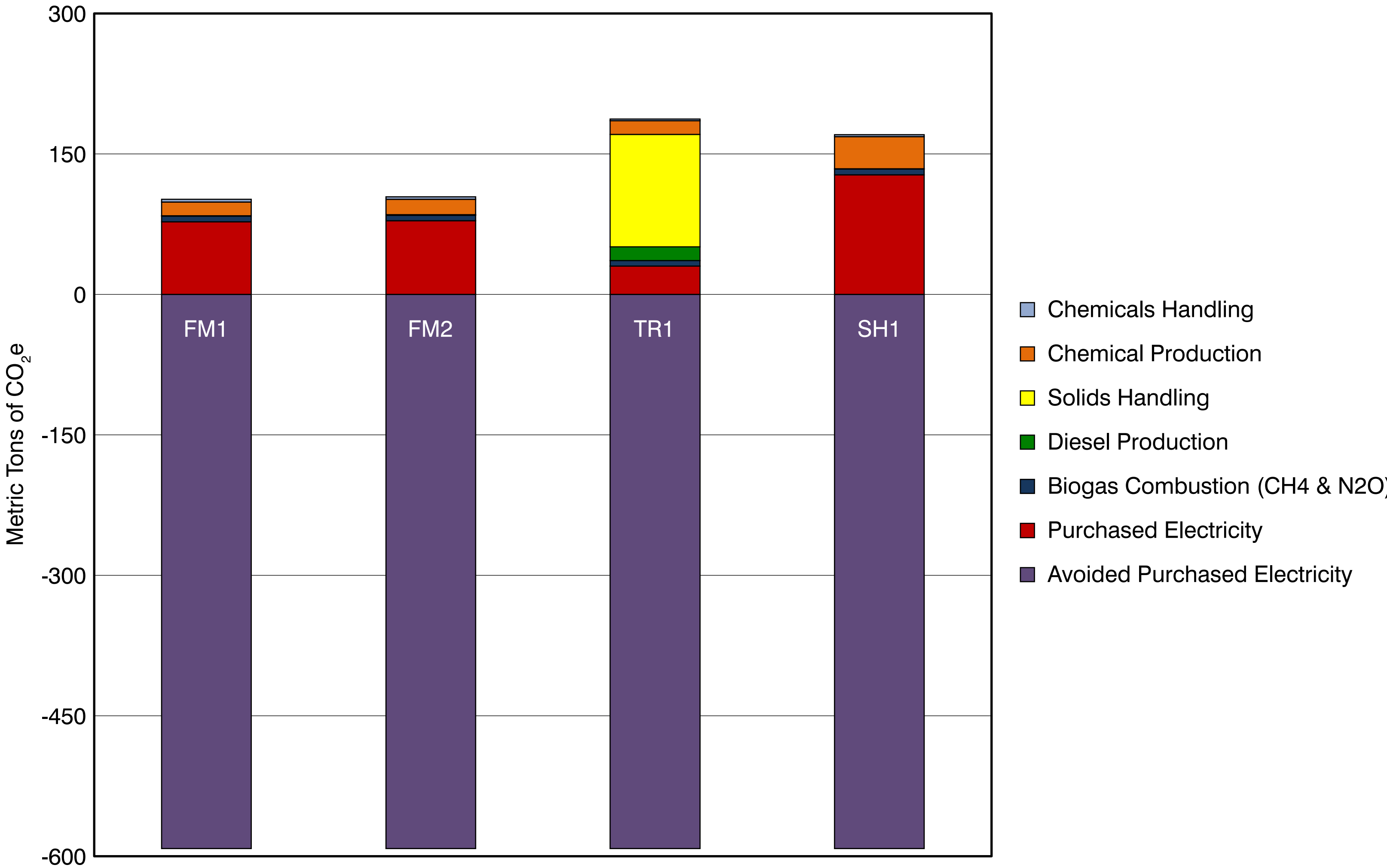

Figure 2

ANNUAL METRIC TONS OF CARBON DIOXIDE EQUIVALENT EMISSIONS DUE TO OPERATIONS NOT INCLUDING CARBON DIOXIDE EMISSIONS FROM BIOGAS COMBUSTION

COASTAL TREATMENT PLANT SLUDGE EXPORT SYSTEM REPLACEMENT

SOUTH ORANGE COUNTY WASTEWATER AUTHORITY

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Table 8	Annual Carbon Dioxide Equivalent Emissions for Additional Power for Pumping Raw Wastewater Coastal Treatment Plant Sludge Export Replacement Project South Orange County Wastewater Authority		
	Purchased Electricity for Pumping	**SH1 Total Metric Tons CO_2e (no biogenic CO_2)(1)**	**Total Metric Tons CO_2e (no biogenic CO_2)(1)**
ECTP1	10	788 (-421)	798 (-411)
ECTP2	70	788 (-421)	858 (-351)
ECTP3	83	788 (-421)	871 (-338)
ECTP4	102	788 (-421)	890 (-319)

Note:

(1) Shows both the value including biogenic emissions (carbon dioxide emissions resulting from the combustion of biogas) and the value not including biogenic emissions (in parentheses).

5.0 EQUIVALENT ELECTRICAL CONSUMPTION

Table 9 shows the total metric tons of CO_2e generated by alternatives FM1, FM2, TR1, and SH1 (including the ECTP alternatives), as well as the equivalent amount of electricity that would need to be consumed in a year to generate that amount of CO_2e emissions.

Table 9	Equivalent Electrical Consumption Coastal Treatment Plant Sludge Export Replacement Project South Orange County Wastewater Authority	
	Total Metric Tons CO_2e (no biogenic CO_2)1	**Equivalent Electricity Consumption (kWh)1**
FM1	719 (-491)	1,804,000 (-1,231,000)
FM2	722 (-488)	1,811,000 (-1,224,000)
TR1	805 (-405)	2,020,000 (-1,015,000)
SH1	788 (-421)	1,977,000 (-1,057,000)
ECTP1 – SH1	798 (-411)	2,002,000 (-1,031,000)
ECTP2 – SH1	858 (-351)	2,153,000 (-881,000)
ECTP3 – SH1	871 (-338)	2,185,000 (-848,000)
ECTP4 – SH1	890 (-319)	2,233,000 (-800,000)

Note:

(1) Shows both the value including biogenic emissions (carbon dioxide emissions resulting from the combustion of biogas) and the value not including biogenic emissions (in parentheses). Negative values represent a net sink for emissions or net generation of electricity.

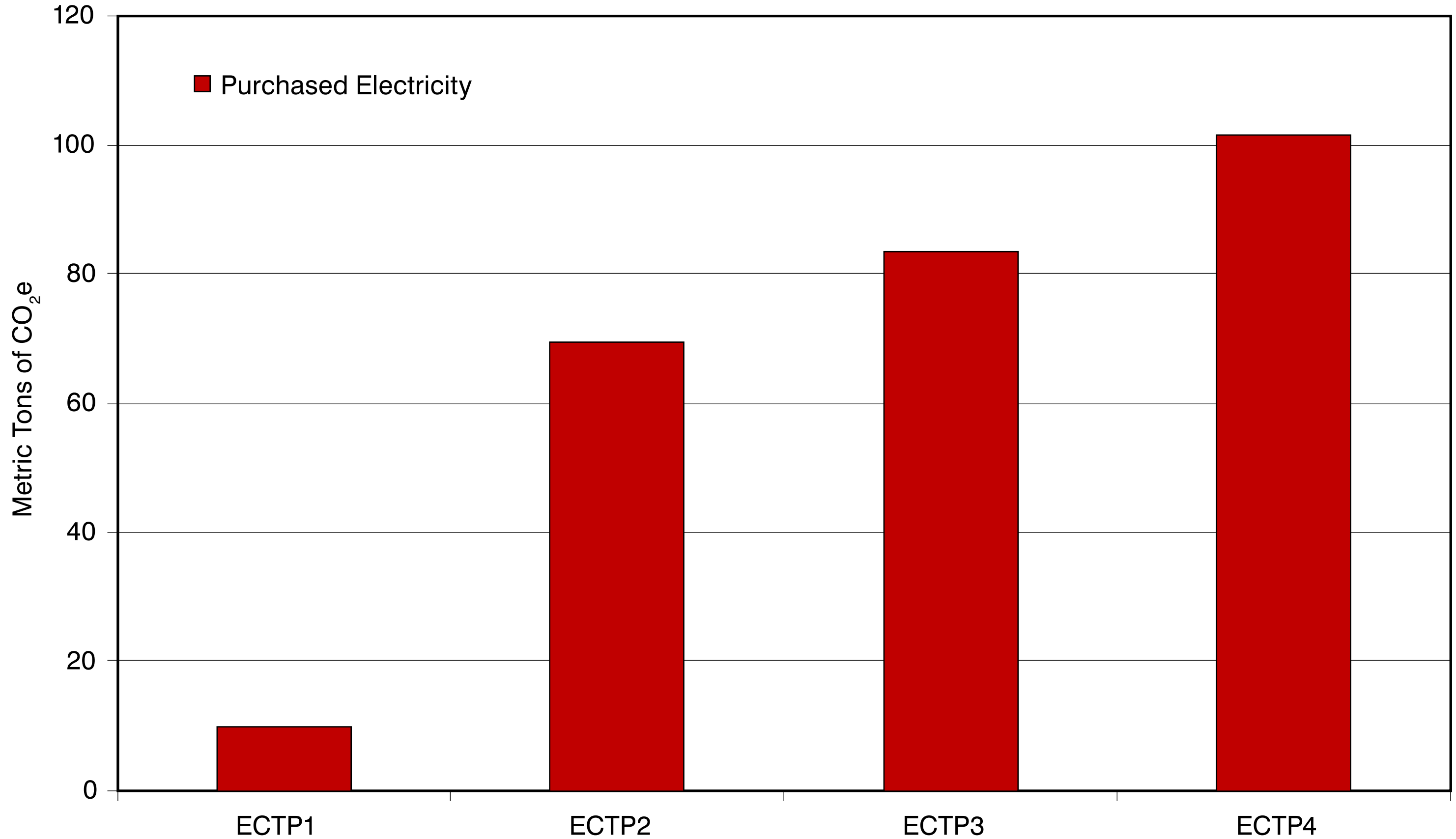

Figure 3
ANNUAL METRIC TONS OF CARBON DIOXIDE EQUIVALENT EMISSIONS DUE TO INCREASED ELECTRICITY CONSUMPTION FOR PUMPING RAW WASTEWATER
COASTAL TREATMENT PLANT SLUDGE EXPORT SYSTEM REPLACEMENT
SOUTH ORANGE COUNTY WASTEWATER AUTHORITY

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APPENDIX - GHG EMISSIONS SUMMARY

GHG EMISSIONS SUMMARY: Alternatives FM1, FM2, TR1, and SH1

	Subregion Electricity Emission Factors, **gCO_2e/kWh**	Petroleum Fuel Emission Factors, **kg/MMBtu**	Natural Gas Emission Factors, **kg/MMBtu**
Carbon Dioxide (CO_2)	398.6	10.15	53.02
Methane (CH_4)	0.0638	0.002	0.001
Nitrous Oxide (N_2O)	0.0422	0.0006	0.0001

Legend
Inputs
Calculations
Carried Over
Not applicable

	Global Warming Potential
Carbon Dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous Oxide (N_2O)	310

INDIRECT EMISSIONS

Table 1. CO_2-Equivalent Emissions Resulting from Electricity Consumption for Operation of the Treatment Facility & Pumping Stations

	Annual Electricity Consumption (kWh)	**Multiply by Average Emission Factor, gCO_2e**			**Total CO_2e Emissions not including T&D Loss**	
		Carbon Dioxide	**Methane**	**Nitrous Oxide**	**g CO_2e**	**Metric Tons CO_2e**
FM1	194,329	77,454,842	12,402	8,196	77,475,440	77
FM2	196,836	78,454,071	12,562	8,302	78,474,935	78
TR1	75,274	30,002,397	4,804	3,175	30,010,375	30
SH1	294,726	117,470,659	18,810	12,430	117,501,899	118

Table 2. CO_2-Equivalent Emissions Resulting from the Production of Chemicals

	Specific Energy for Production			**CO_2e Generated per Chemical Produced**			
Chemical Name	**Energy Source**	**Factor**	**Units**	**FM1**	**FM2**	**TR1**	**SH1**
Sodium Hypochlorite	Electricity	2.5	kWh/lb	14,521,985	14,521,985	14,521,985	0
Sodium Hydroxide	Electricity	1.5	kWh/lb	0	0	0	34,446,109
Ferric Chloride	Electricity	0.05	kWh/lb	168,074	2,016,891	0	0
Total Metric Tons CO_2e:				**15**	**17**	**15**	**34**

Table 3. Offsets: CO_2-Equivalent Emissions Avoided through Generation/Use of Renewable Energy Versus Purchasing Electricity

	Annual Electricity Consumption (kWh)	**Multiply by Average Emission Factor, gCO_2e**			**Total CO_2e Emissions not including T&D Loss**	
		Carbon Dioxide	**Methane**	**Nitrous Oxide**	**g CO_2e**	**Metric Tons CO_2e**
FM1	1,484,562	591,710,346	94,745	62,611	591,867,702	592
FM2	1,484,562	591,710,346	94,745	62,611	591,867,702	592
TR1	1,484,562	591,710,346	94,745	62,611	591,867,702	592
SH1	1,484,562	591,710,346	94,745	62,611	591,867,702	592

		Carbon Dioxide		**Methane**		**Nitrous Oxide**	
Vehicle Type/ Model Year	**Fuel**	Emission Factor kg/gal	Fuel Efficiency (mpg)	Emission Factor g/VMT	GWP, 100 yr TH	Emission Factor g/VMT	GWP, 100 yr TH
Heavy Duty - 1998	CA Diesel	9.96	5.65	0.06	21	0.05	310

Table 4. CO_2-Equivalent Emissions Resulting from Production of Diesel for Transport of Construction Materials, Solids, and/or Chemicals

	Annual Gallons Diesel	Carbon Dioxide (kg CO2/year)	Methane (g CO2e/year)	Nitrous Oxide (g CO2e/year)	Total CO2e Emissions kilograms/year	Metric Tons/year
FM1	271	324	10	0	324	**0.3**
FM2	271	324	10	0	324	**0.3**
TR1	12,176	14,526	470	5	14,526	**14.5**
SH1	200	239	8	0	239	**0.2**

Table 5. CO_2-Equivalent Emissions Resulting from Fuel Consumption for Solids Handling (including fuel consumed during idling)

	Annual VMT	Annual Gallons Diesel	Carbon Dioxide (kg CO2/year)	Methane (g CO2e/year)	Nitrous Oxide (g CO2e/year)	Total CO2e Emissions kilograms/year	Metric Tons/year
FM1	0	0	0	0	0	0	**0**
FM2	0	0	0	0	0	0	**0**
TR1	41,975	11,990	119,423	52,889	650,613	120,126	**120**
SH1	0	0	0	0	0	0	**0**

Table 6. CO_2-Equivalent Emissions Resulting from Fuel Consumption for Chemicals Handling

	Annual VMT	Annual Gallons Diesel	Annual Freighter Gallons	Carbon Dioxide (kg CO2/year)	Methane (g CO2e/year)	Nitrous Oxide (g CO2e/year)	Total CO2e Emissions kilograms/year	Metric Tons/year
FM1	1,900	271	0	2,703	2,394	29,450	2,735	**3**
FM2	1,900	271	0	2,703	2,394	29,450	2,735	**3**
TR1	1,300	186	0	1,850	1,638	20,150	1,872	**2**
SH1	1,400	200	0	1,992	1,764	21,700	2,015	**2**

DIRECT EMISSIONS

ONSITE COMBUSTION SOURCES

Table 7. CO_2-Equivalent Emissions Resulting from Biogas Combustion

	Annual Biogas Consumption (cubic feet)	CO_2e Emissions Calculated using Emission Factors (kg)			Total Metric Tons CO_2e (includes Biogenic CO_2)	Metric Tons CO_2e (Only CH_4 & N_2O)
		Carbon Dioxide	Methane	Nitrous Oxide		
FM1	27,629,040	1,209,900	1,561	4,538	**1,216**	**6.10**
FM2	27,629,040	1,209,900	1,561	4,538	**1,216**	**6.10**
TR1	27,629,040	1,209,900	1,561	4,538	**1,216**	**6.10**
SH1	27,629,040	1,209,900	1,561	4,538	**1,216**	**6.10**

TOTAL (Indirect + Direct) EMISSIONS

Summary Table - Annual Total Metric Tons of Carbon Dioxide Equivalent Emissions

	Avoided Purchased Electricity	Purchased Electricity	Biogas Combustion	Biogas Combustion (CH4 & N2O)	Diesel Production	Solids Handling	Chemical Production	Chemicals Handling	TOTAL Metric Tons CO_2e Emissions	TOTAL Metric Tons CO_2e Emissions (no Biogenic CO2)
FM1	-592	77	1,216	6.1	0.3	0	15	3	**719**	**-491**
FM2	-592	78	1,216	6.1	0.3	0	17	3	**722**	**-488**
TR1	-592	30	1,216	6.1	14.5	120	15	2	**805**	**-405**
SH1	-592	128	1,216	6.1	0.2	0	34	2	**789**	**-421**

GHG EMISSIONS SUMMARY: Alternatives ECTP1 through ECTP4

	Subregion Electricity Emission Factors, **gCO_2e/kWh**	Petroleum Fuel Emission Factors, **kg/MMBtu**	Natural Gas Emission Factors, **kg/MMBtu**
Carbon Dioxide (CO_2)	398.6	10.15	53.02
Methane (CH_4)	0.0638	0.002	0.001
Nitrous Oxide (N_2O)	0.0422	0.0006	0.0001

Legend
Inputs
Calculations
Carried Over
Not applicable

	Global Warming Potential
Carbon Dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous Oxide (N_2O)	310

INDIRECT EMISSIONS

Table 1. CO_2-Equivalent Emissions Resulting from Electricity Consumption for Operation of the Treatment Facility & Pumping Stations

	Annual Electricity Consumption (kWh)	**Multiply by Average Emission Factor, gCO_2e**			**Total CO_2e Emissions not including T&D Loss**	
		Carbon Dioxide	**Methane**	**Nitrous Oxide**	**g CO_2e**	**Metric Tons CO_2e**
ECTP1	24,820	9,892,652	1,584	1,047	9,895,283	10
ECTP2	174,470	69,539,524	11,135	7,358	69,558,017	70
ECTP3	209,145	83,360,141	13,348	8,821	83,382,310	83
ECTP4	254,770	101,545,163	16,260	10,745	101,572,168	102

TOTAL (Indirect + Direct) EMISSIONS

Summary Table - Annual Total Metric Tons of Carbon Dioxide Equivalent Emissions

	Purchased Electricity	**TOTAL Metric Tons CO_2e Emissions**	**TOTAL Metric Tons CO_2e Emissions (no Biogenic CO2)**
ECTP1	10	**10**	**10**
ECTP2	70	**70**	**70**
ECTP3	83	**83**	**83**
ECTP4	102	**102**	**102**