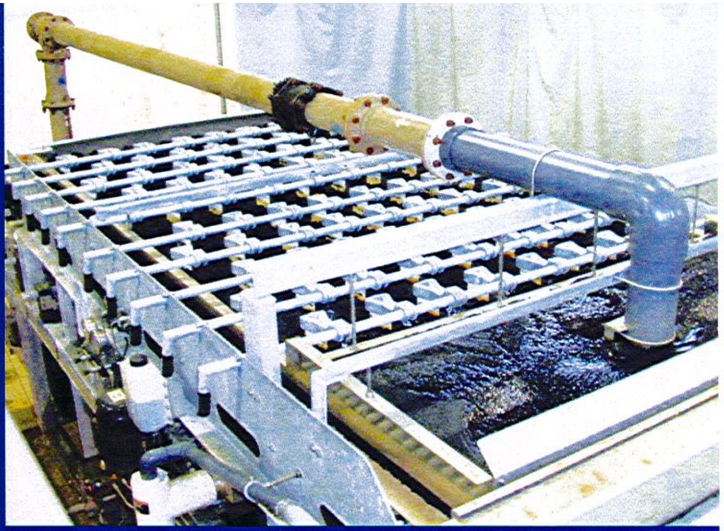

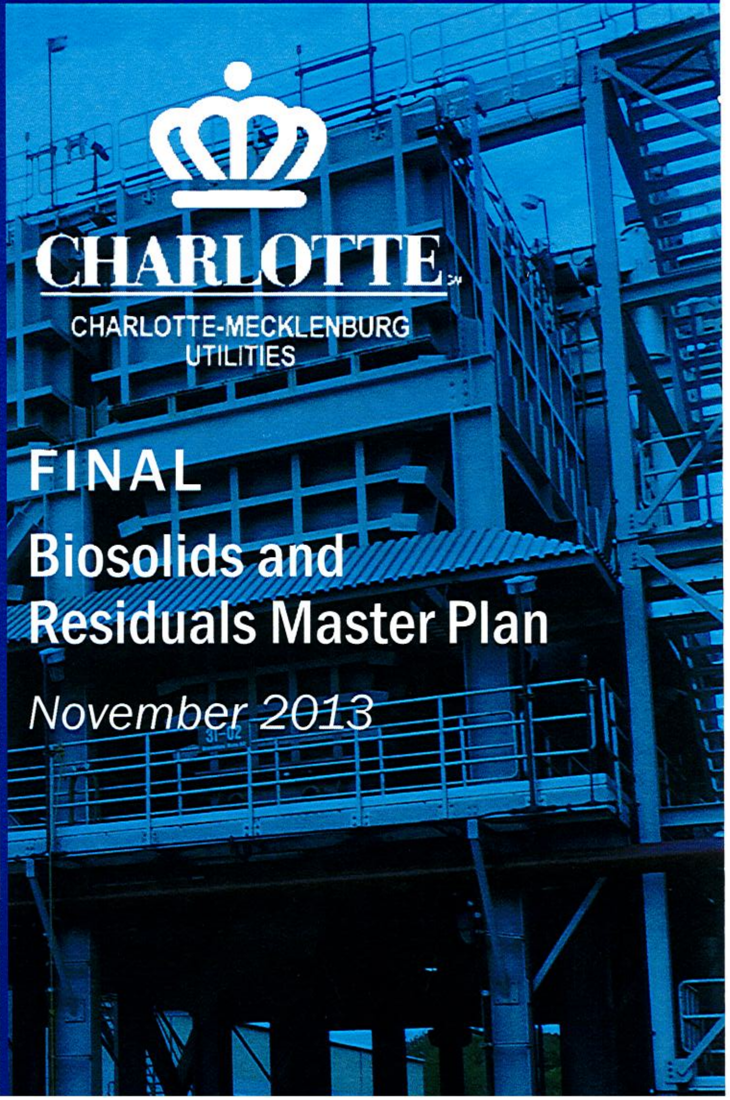

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Biosolids and Residuals Master Plan

November 2013

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BIOSOLIDS AND RESIDUALS MASTER PLAN

FINAL

November 2013

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11/20/13

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Executive Summary

Introduction

This Biosolids and Residuals Master Plan presents a balanced life-cycle cost-based, environmentally sound and publically acceptable approach to meet CMUD's short- and long-term residuals processing needs. In order to provide recommendations for a long term residuals management plan, CDM Smith developed projections of future flows and residuals characteristics and volumes and evaluated the financial, environmental and social sustainability of numerous residuals management strategies, including that which is employed currently. For each management strategy, CDM Smith identified currently available technology options for residuals treatment and handling processes and determined probable costs for the evaluated processing upgrades. Anticipated regulatory changes and emerging social-political issues were identified and their impact considered. CDM Smith analyzed the potential risks and benefits associated with each strategy by addressing financial, regulatory, environmental, and public relations considerations.

The existing residuals management program has various limitations including:

- **Single disposal outlet** – Class B land application (except for non-conforming residuals that are landfilled) is the sole disposal option, which has a long term relatively high risk since there is concern of diminishing land availability due to urbanization and, in addition, public concerns about Class B biosolids land application.

- **Dependence on one independent contractor-** There is some risk involved in relying on an external party for managing 100% of the residuals in the event contractor becomes unable to meet contractual terms with CMUD in the future.

- **Relatively poor dewatering performance at WWTPs** – all WWTPs have challenges regarding dewatering, from low solids cake concentration to fecal coliform regrowth issues.

- **Lack of resource recovery** – For example, the existing WWTPs are not capable of generating power from digester biogas.

- **No Class A biosolids -** No production of Class A biosolids is currently available at CMUD operations. Class A biosolids provide better opportunities to have diverse disposal options.

- **WTP On Site Dewatering Limitations** – Neither Vest WTP or Lee S. Duke WTP have dewatering capabilities on site. Currently, Vest hauls liquid residuals to Franklin WTP and Lee S. Duke's transfers thickened residuals into an on-site lagoon which is then pumped into trucks for land application.

The management strategies presented in this master plan aim at addressing the limitations of the existing biosolids and residuals management program. The following key drivers were identified for the development of management strategies:

- Achieve a long-term sustainable biosolids and residuals program.
- Mitigate risk.
- Provide multiple distribution outlets for end product.
- React to potential future changes in environmental regulations.
- Consider public perception of treatment processes and residuals products.
- Consider potential resource recovery opportunities and optimization.
- Address the possibility for regionalization.

The evaluated strategies accounted for the long-term dependability and sustainability of land application and landfilling. In particular, the feasibility of Class B land application is of increasing concern. Interest in Class A products has gained momentum in recent years in part because they can be potentially distributed and marketed, and Class A biosolids do not raise the same level of public concern as Class B biosolids when land applied.

Biosolids and Residuals Production

Wastewater Treatment Plant Biosolids Production

Current and projected solids production from year 2015 to year 2035 was estimated on the basis of current solids characteristics and wastewater flow projections at each WWTP. Primary and secondary solids loading rates were obtained from daily records between year 2009 and year 2011, when available, or from the results of mass balance calculations calibrated against disposal data reported by Synagro. The recommended basis of design for biosolids handling equipment for future conditions at each WWTP is summarized in **Table ES-1**.

Table ES-1 Projected Biosolids Production

Facility	Year	Annual Average Flow (mgd)	Primary Clarifier Solids (Dry Tons per Day)		WAS (Dry Tons per Day)		Total Solids Production (Dry Tons per Day)	
			Annual Average Day	Max Month	Annual Average Day	Max Month	Annual Average Day	Max Month
Sugar Creek WWTP	2015	13	7.9	10	5.3	7.1	13.2	17.1
	2020	13	7.9	10	5.3	7.1	13.2	17.1
	2025	16	9.7	12.3	6.6	8.7	16.2	21
	2030	16	9.7	12.3	6.6	8.7	16.2	21
	2035	16	9.7	12.3	6.6	8.7	16.2	21
McAlpine Creek WWMF	2015	48.8	32.2	45.1	18.5	26	50.8	71.1
	2020	46.4	30.6	42.9	17.6	24.7	48.3	67.6
	2025	50	33	46.2	19	26.6	52	72.8
	2030	53.9	35.6	49.8	20.5	28.7	56.1	78.5
	2035	58.3	38.5	53.9	22.2	31	60.6	84.9

Facility	Year	Annual Average Flow (mgd)	Primary Clarifier Solids (Dry Tons per Day)		WAS (Dry Tons per Day)		Total Solids Production (Dry Tons per Day)	
			Annual Average Day	Max Month	Annual Average Day	Max Month	Annual Average Day	Max Month
Irwin Creek WWTP	2015	8.5	6.5	7.5	4	5.5	10.5	13
	2020	11.8	9	10.4	5.6	7.7	14.6	18.1
	2025	12.4	9.5	10.9	5.9	8.1	15.4	19
	2030	13	9.9	11.4	6.2	8.5	16.1	19.9
	2035	13.5	10.3	11.9	6.4	8.8	16.8	20.7
Mallard Creek WRF	2015	8.5	4.8	5.8	3.2	4	8	9.8
	2020	8.9	5	6.1	3.3	4.2	8.4	10.3
	2025	9.2	5.2	6.3	3.4	4.3	8.6	10.6
	2030	9.5	5.4	6.5	3.5	4.5	8.9	11
	2035	9.8	5.6	6.7	3.6	4.6	9.2	11.3
McDowell Creek WRF	2015	4.8	3.5	4.4	3.2	4	6.8	8.3
	2020	5.1	3.8	4.6	3.4	4.2	7.2	8.9
	2025	5.3	3.9	4.8	3.6	4.4	7.5	9.2
	2030	5.6	4.1	5.1	3.8	4.6	7.9	9.7
	2035	5.9	4.4	5.4	4	4.9	8.3	10.3
Long Creek WWTP	2020	7.5	5.7	6.6	3.6	4.9	9.3	11.5
	2025	7.9	6	7	3.8	5.2	9.8	12.1
	2030	8.3	6.3	7.3	4	5.4	10.3	12.7
	2035	8.7	6.7	7.7	4.1	5.7	10.8	13.3

Water Treatment Plant Residuals Production

CDM Smith evaluated historic and projected water supply and residuals production for Franklin, Vest, and Lee S. Dukes WTPs up to year 2035. The projections were based on a previous water system master plan (Black and Veatch, 2008), historical daily data collected between 2009 and 2011, and feedback provided by CMUD staff. The recommended basis of design for solids handling equipment for future conditions is summarized in **Table ES-2**.

Table ES-2 Projected WTP Residuals Production

Year	Max Month Residuals Production (Dry Tons per Day)			
	Franklin WTP	Vest WTP	Lee S. Dukes WTP	Total
2015	6.1	1.4	1.0	8.5
2020	6.7	1.4	1.1	9.2
2025	7.4	1.8	1.2	10.4
2030	8.2	1.8	1.3	11.3
2035	9.0	1.8	1.3	12.1

Residuals Management Alternatives

In the development of this Master Plan, CDM Smith considered a multitude of alternatives, described in detail in Section 8. In collaboration with and input from CMUD, the scope of alternatives was pared-down to three different WTP residuals management alternatives and 10 different WWTP biosolids management alternatives, shown in **Table ES-3** through **Table ES-9**. The alternatives considered various combinations of different technologies.

Table ES-3 Strategy 1 Current WWTP Biosolids Management Strategies (Baseline)

WWTP	McAlpine	Irwin	Mallard	McDowell
Alternative 1-1	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion

Table ES-4 Strategy 1-B Current WTP Residuals Management Strategies (Baseline)

WTP	Franklin	Vest	Lee S. Dukes
Alternative 1B-1	Dewatering of residuals produced at Franklin and Vest	Liquid residuals transported to Franklin	Land application of residuals withdrawn from lagoon

Table ES-5 Strategy 3 Pretreatment and Anaerobic Digestion Alternatives

WWTP	McAlpine	Irwin	Mallard	McDowell
Alternative 3-4	Add THP* upstream of Anaerobic Digestion	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion
Alternative 3-6	Add THP upstream of Anaerobic Digestion	Pump liquid sludge to McAlpine for treatment	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion
Alternative 3-7	Add ELP** upstream of Anaerobic Digestion	Add ELP upstream of Anaerobic Digestion	Add ELP upstream of Anaerobic Digestion	Add ELP upstream of Anaerobic Digestion
Alternative 3-8	Add THP upstream of Anaerobic Digestion	Add ELP upstream of Anaerobic Digestion	Add ELP upstream of Anaerobic Digestion	Add ELP upstream of Anaerobic Digestion

*THP refers to the Thermal Hydrolysis Process

**ELP refers to the Electrical Lysis Process

Table ES-6 Strategy 4 Anaerobic Digestion and Drying Alternatives

WWTP	McAlpine	Irwin	Mallard	McDowell
Alternative 4-4	Add thermal dryer downstream of dewatering	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion
Alternative 4-12	Add thermal dryer downstream of dewatering	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion	Add solar dryer downstream of dewatering

Table ES-7 Strategy 3+4 Pretreatment, Anaerobic Digestion, and Drying Alternatives

WWTP	McAlpine	Irwin	Mallard	McDowell
Alternative 3+4-1	Add THP upstream of anaerobic digestion and thermal drying downstream of anaerobic digestion	Maintain anaerobic digestion	Maintain anaerobic digestion	Maintain anaerobic digestion
Alternative 3+4-2	Add THP upstream of anaerobic digestion and thermal drying downstream of anaerobic digestion	Pump liquid sludge to McAlpine for treatment	Maintain anaerobic digestion	Maintain anaerobic digestion
Alternative 3+4-3	Add THP upstream of anaerobic digestion and thermal drying downstream of anaerobic digestion	Add ELP upstream of anaerobic digestion	Add ELP upstream of anaerobic digestion	Add ELP upstream of anaerobic digestion

Table ES-8 Strategy 10 Third Party Contracting Alternatives

WWTP	McAlpine	Irwin	Mallard	McDowell
Alternative 10	Third Party Contractor disposes of dewatered cake	Third Party Contractor disposes of dewatered cake	Third Party Contractor disposes of dewatered cake	Third Party Contractor disposes of dewatered cake

Table ES-9 Strategy 11 WTP Residuals Dewatering and Pumping Alternatives

WTP	Franklin	Vest	Lee S. Dukes
Alternative 11-1	Dewater On-Site and Provide Dewatered Solids Storage	Liquid residuals pumped to Franklin	Dewater On-Site
Alternative 11-2	Residual Discharge to Sewer; No Treatment On-Site	Residual Discharge to Sewer; No Treatment On-Site	Residual Discharge to Sewer; No Treatment On-Site

Evaluation Criteria

The biosolids and residuals alternatives were subjected to two different evaluations, one based upon cost and the other based upon qualitative criteria. Section 9 establishes the framework for this analysis, defining general cost assumptions and the qualitative criteria used for the evaluation. A mass balance was developed for each management alternative to determine solids and hydraulic loadings at each step in the process train. Generally, the equipment was sized based on the results of the mass balance for projected maximum month solids production in year 2035. When feasible and cost effective, phased implementation was considered for the selected biosolids and residuals alternatives. Phased implementation would allow the timing of capital expenditures to be adjusted based on changes in sludge loading rates, economic conditions, or the availability of funds.

An opinion of probable construction cost was developed to compare alternatives relative to one another. In addition to direct construction costs (equipment, labor, and materials), capital cost estimates include a number of indirect costs, including such markups as sales tax on equipment, permits, engineering services, and contingencies. All capital costs in this report are reported in January 2013 dollars.

A ranking process was used to rate alternatives based on both cost and non-cost factors. This method consisted of developing weighting factors on a 1 to 5 scale to be assigned to each criterion and rating the performance of each alternative in meeting each criterion on a 1 to-10 scale. The weighting factors for each criterion were established by surveying CMUD staff and are presented in **Table ES-10.**

Table ES-10 Rating Considerations for Alternatives Evaluation Criteria

Criteria (Weight)	Description/Rating General Comments
Long Term Viability/ Sustainability (5)	*Long-term viability is defined as the ability to meet the biosolids and residuals handling, treatment, and disposal/end use requirements throughout the planning period. This includes identifying technologies that are durable and are capable of meeting anticipated regulatory changes, ensuring that there is a sustainable market for the biosolids end product, and quantifying potential changes in energy costs that may impact treatment options, etc.*
	Thermal hydrolysis and thermal drying received high ratings due to the ability to provide multiple outlets and meet future, more stringent regulations. Treating solids from Irwin Creek WWTP at McAlpine Creek WWMF was also a positive factor. Combining thermal hydrolysis with thermal drying further improves the ability of McAlpine Creek WWMF to become a more sustainable operation in the future. Maintaining current operations received the lowest rating as it will not enable CMUD to differentiate their current Class B limited disposal options.
Reliability (5)	*Ability of a given treatment process to consistently perform in accordance with the intended design and function of the system with minimal down time. A reliable system aims at optimizing its performance. Systems that require extensive equipment may be considered less reliable than other less equipment or chemical dependent systems.*
	Thermal drying is an established technology that performs reliably. Thermal hydrolysis is emerging as a process that performs consistently achieving Class A and improved dewatering capabilities. The combination of the two would enhance the process and would allow to ensure delivery of a Class A pelletized final product. The current operations are seen as unreliable due to the ongoing issues with the dewatering process at McAlpine Creek WWMF.
O&M Cost (5)	*Operation and maintenance costs compared to current practices.* *Includes energy consumption required for process.*
	O&M costs are impacted by the complexity of thermal drying and thermal hydrolysis, and the use of natural gas. However, the reduced volume of solids translates into less disposal costs, as further discussed in this Section
Process Maintainability (4.5)	*The ease in which a treatment process is maintained. Accessibility of equipment, required spare parts inventory, availability of parts, and special tools or skill requirements are associated with the maintainability of a treatment system.*
	Maintenance of operations received a high rating as it is relatively easy and proven, while thermal hydrolysis and drying require significant monitoring and control of operations, and therefore received lower ratings. Pumping sludge from Irwin increased the rating as it is associated to phasing out the facilities at this Irwin Creek WWTP.
Impact on Existing Facilities (4)	*Potential impacts on existing processes, including potential for air quality/odor impacts during processing.*
	The impact on existing facilities is high with thermal hydrolysis, relatively modest with the addition of thermal drying and minimum with maintenance of current operations.
Proven Technology (3.5)	*This criterion relates to utilizing technologies with a proven history of success. This includes technology that may not yet be widely utilized in the US but have a proven history of success worldwide.*
	With the exception of electrical lysis which is an innovative technology, all other processes are established. Thermal drying has been used successfully for decades at several facilities. Thermal hydrolysis is rapidly becoming a proven technology that performs well at various facilities overseas.

Criteria (Weight)	Description/Rating General Comments
Operability/ Ease of Use (3.5)	*The ease of operation of a treatment system. The amount and type of operator attention and the degree of automation are both aspects of the operability of a treatment system. Some alternatives may require a high degree of control for efficient operation, while others may require less.*
	The more complex technologies received lower ratings as they are more difficult to operate
Risk Management (3)	*This criterion relates to how much risk is associated with a given alternative and the degree to which the risk can be managed (i.e., is the market for the product end use guaranteed, are all cost impacts (current and future) fully understood and captured, etc.)*
	Risk management is offset by the installation of Class A technologies such as thermal hydrolysis and drying, and is further mitigated by the combination of the two. Maintaining current operations may become a critical asset with increased public awareness and limited options for disposal of Class B biosolids.
Side Stream Impacts (3)	*Some of the biosolids management technologies (such as anaerobic digestion technologies) can generate return flows that have high concentrations of ammonia and phosphorous. This high nutrient loading may upset the liquid treatment and may result in high levels of nitrogen and phosphorous in the effluent. However, while the sidestream associated to dewatering is a challenge, it is also an opportunity for nutrient recovery. Once the nutrients are out of the solids stream, they are easier to recover.*
	Thermal hydrolysis generates the elevated phosphorus levels downstream of digestion and therefore had the lowest rating. Note however that implementation of a phosphorus removal system allows to recover the nutrients and market them. Maintenance of current operations scored high as it is associated to the lowest levels of nutrients being produced in the dewatering process.
Public Perception/ Acceptance (2)	*This criterion includes the positive or negative impact each alternative has on the surrounding community including residents and businesses near the WWTP and at biosolids land application locations. Public acceptance includes environmental, aesthetic, and ergonomic factors such as traffic, noise, odor, and visual appeal*
	Public awareness of issues associated to land application of Class B biosolids has grown over time and therefore all options associated to production of Class A biosolids were given high ratings. The combination of thermal hydrolysis and drying at McAlpine Creek WWMF, coupled with the reduction in operations at Irwin Creek WWTP, received the highest rating as it would substantially decrease the level of solids generated and operations at Irwin Creek WWTP.
Flexibility/ Adaptability (2)	*Ability of a proposed alternative to accommodate the varying conditions of flow, waste load, maintenance service needs, etc., and still meet regulatory permit requirements and being able to adapt based on current conditions. Some alternatives may require major additional capital expenditures that hinder cost-effective improvements should permit conditions or other factors such as flows and loadings to the facilities change.*
	The more complex options received the highest ratings as they provide multiple outlets for the final product which would be Class A and marketable.

Criteria (Weight)	Description/Rating General Comments
Resource Recovery Opportunities (2)	*Optimization of all potential resource recovery opportunities can contribute to a successful policy for disposal of the final product.*
	Thermal hydrolysis coupled with thermal drying provides the greatest opportunity to market the final product and reduce sidestreams by means of recovery of elevated phosphorus levels. The other options involving thermal hydrolysis and drying also score high.
Partnerships and Regionalization (1)	*Ability to create a regional facility with the intent to incur several benefits, such as reduced capital cost by providing a single facility, single location for collection of end product, more cost effective and simpler O&M, holistic approach to biosolids treatment and disposal.*
	The highest ratings were received by the alternatives that plan on processing the Irwin Creek WWTP sludge at McAlpine Creek WWMF. Achieving Class A with thermal hydrolysis and drying is also seen as a potential incentive for other municipalities to treat their sludge at McAlpine Creek WWMF in the future.
Capital Cost (1)	*Opinion of Probable Construction Cost in year 2013 dollars.*
	The construction cost associated to thermal hydrolysis and drying is substantial, and therefore these alternatives scored low ratings, while maintenance of current operations received the highest rating, as expected.

CDM Smith staff then rated the performance of each alternative by assigning a 1 to 10 score to each criterion. A “1” signifies that the alternative performs poorly, while a “10” signifies excellent performance. The evaluation criteria, criteria weighting and the ratings of each alternative with respect to the criteria were entered into a decision model to identify the preferred alternative from a qualitative perspective. CDM Smith utilized a proprietary software package, Criterium Decision Plus (CDP), to facilitate the analyses.

The lifecycle greenhouse gas (GHG) emissions associated with each management alternative were estimated using nominal assumptions about the treatment processes and disposal outlets involved.

Recommended Capital Improvement Plan

Biosolids Management Improvements

Based on the extensive evaluation, Alternative 3+4-2 is the recommended WWTP biosolids alternative, due to its alignment with CMUD’s goals and taking into account potential risk and the degree of operational flexibility it affords. This alternative implements thermal hydrolysis coupled with thermal drying at McAlpine Creek WWMF which would also receive and process primary and waste activated sludge pumped from Irwin Creek WWTP. Mallard Creek WRF and McDowell Creek WRF would continue to maintain current operations.

McAlpine Creek WWMF - Thermal Hydrolysis Coupled with Anaerobic Digestion and Thermal Drying

At McAlpine Creek WWMF, the process flow train will include blending of WAS and primary solids, screening, pre-dewatering followed by thermal hydrolysis, anaerobic digestion and final dewatering. The stabilized biosolids will then be fed to a thermal dryer consisting of a rotary drum dryer producing a pelletized Class A material ready for distribution and marketing. A process flow diagram is shown in **Figure ES-1**.

Thermal hydrolysis offers several benefits including decreased biosolids volume which means less final product to manage. Thermal hydrolysis also increases biogas production which can be beneficially reused as a fuel source. Most notably, though, thermal hydrolysis produces odorless, Class A product without risk of fecal regrowth issues.

Thermal Dryers are also recommended for implementation at McAlpine Creek WWMF. Thermal dryers produce dry pellets that meet Class A biosolids requirements for pathogen reduction and significantly reduces product volume, which facilitates transportation to more distant markets. It is also suitable for distribution and marketing as a fertilizer or soil conditioner, instead of being land applied.

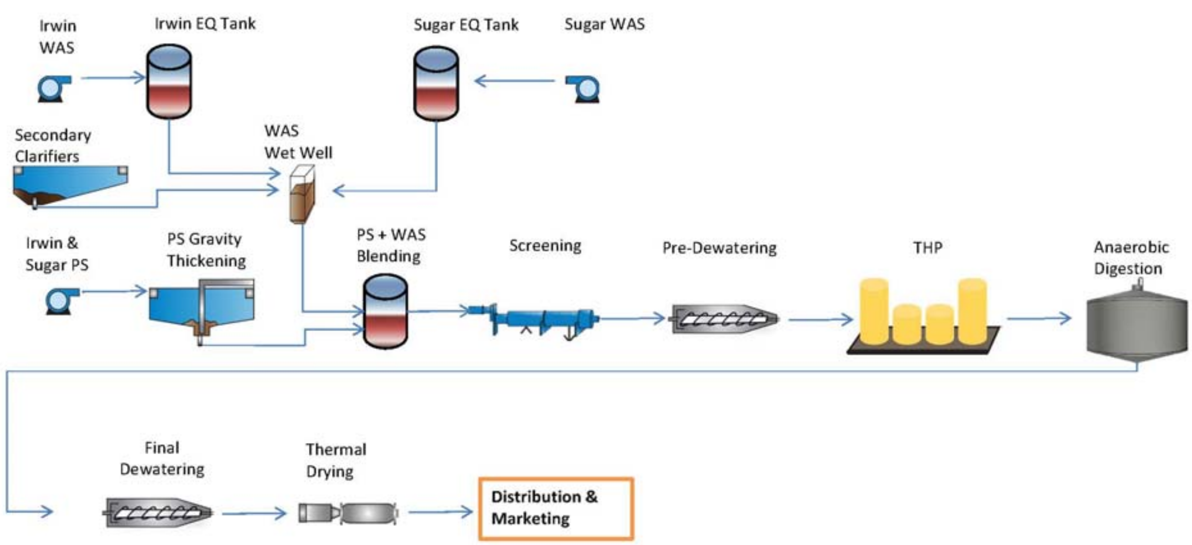

Figure ES-1
Recommended Alternative – McAlpine Creek WWMF Process Flow Diagram

Irwin Creek WWTP – Sludge Transfer to McAlpine Creek WWMF

It is recommended that unthickened primary solids and WAS will be pumped to McAlpine Creek WWMF from Irwin Creek WWTP for processing and handling. Two new pump stations (one for primary sludge and one for WAS) dedicated to each solids stream will be constructed at Irwin Creek WWTP, and will convey the liquid unstabilized sludge to McAlpine Creek WWMF through separate force mains. The new pipes would run along the same route where an existing sewer line is already installed for an approximate distance of 13.5 miles. The existing biosolids treatment facilities at Irwin Creek WWTP will be phased out once construction of the pipelines/force mains and thermal hydrolysis at McAlpine Creek WWMF is complete. The dewatered cake storage facility will continue to be used for storage of residuals transported from Vest and Franklin WTPs until the new storage facility at Franklin WTP is complete.

Mallard Creek WRF & McDowell Creek WRF - Maintain Current Operations

Mallard Creek WRF and McDowell Creek WRFs are recommended to continue to maintain current operations with mesophilic anaerobic digestion. Some improvements will be necessary in order to maintain current operations.

Other Biosolids Management Improvements

In addition to the facility requirements identified above, there are additional capital improvements needed for the WWTPs to remain in operation for the duration of the planning period. These improvements include:

- 31,000 gallon equalization tank at McAlpine Creek WWMF to receive the WAS pumped from Sugar CrePhosphorus recovery system at McAlpine Creek WWMF to avoid chemicals purchase and sludge disposal costs and take advantage of potential revenues from fertilizer sales.
- Additional dewatering centrifuges at McAlpine Creek WWMF.
- Thickening/dewatering upgrade at Mallard Creek WRF.
- Biogas Conditioning System at Mallard Creek WRF to address corrosion issues in the gas handling system.
- Dewatered biosolids storage facility at McDowell Creek WRF to provide necessary cake storage capacity through the planning horizon.

WTP Residuals Management Improvements

Based on the recommendation outlined in Section 13, Alternative 11-1 is the recommended WTP residuals alternative. This alternative completely separates the disposal of WTP residuals from WWTP biosolids and reduces the number of sludge hauling trucks by pumping residuals from Vest to Franklin WTP. The following proposed capital projects are associated with this recommended alternative:

- *Franklin WTP Dewatered Cake Storage*: Instead of hauling dewatered cake to Irwin, a new Dewatered Solids Storage Facility would be located at Franklin WTP. Trucks would transfer dewatered cake to the storage area from the Dewatering Building. A front-end loader would then be used to move the cake into piles. The same equipment would be used to load trucks with residuals for transport to end use.
- *Vest WTP Pumping Facilities*: It is recommended that the residuals from Vest WTP be pumped at low solids concentrations (less than 1 percent) to Franklin WTP through a new force main. The preliminary pipe route is estimated to be 2.7 miles long. A routing study should be performed to optimize the proposed alignment.
- *Lee S. Dukes WTP Dewatering and Storage Facility*: The solids from the lagoon are currently pumped on vacuum trucks and land applied. One 2-meter belt filter press is proposed to dewater the solids to a cake solids concentration of 25 percent. A 12,000 gal holding tank is proposed for temporary storage of the liquid residuals pumped out from the lagoon. It is proposed that the 2-meter BFP will be housed in a new dewatering building located south-east

of the lagoon. This facility would have a capacity of approximately 400 wet tons, corresponding to storage of the average residuals production projected for year 2035 for 90 days.

Phased Implementation Schedule

Phased implementation of the facilities proposed is recommended as a means of rendering the large capital cost more compatible with CMUD's budget while still meeting the goals of the master plan. This evaluation does not account for replacement of equipment approaching its end of life.

Biosolids Implementation Strategy: **Figure ES-2** is a graphical representation of the recommended implementation schedule/strategy. The strategy consists of phasing in different actions in order to achieve systematic improvements to the biosolids program. In the first phase of the program CMUD should focus on beginning a public information program to help the public understand the commitment that CMUD is making to the environment by embarking on this program. Concurrently, CMUD should begin the implementation of the first major capital projects being recommended including construction of a thermal hydrolysis process and McAlpine as well as constructing the pipelines to transfer solids from Irwin to McAlpine. Some of the benefits that will be seen by implementing these Phase I actions include addressing the fecal regrowth/odor issues, reduction of biosolids total volume, providing for regionalization of treatment, diversification of biosolids end uses and increasing the public awareness regarding the benefits of producing a Class A biosolids.

During Phase II of the program CMUD should reassess the environmental, regulatory and socio-economic issues regarding the implementation of this program. CMUD should consider the pros and cons regarding third party contracting and either renew or issue an RFP for third party land application. Phase II should also include the implementation of last of the major capital projects including the thermal dryer. Once the thermal dryer is constructed the complete benefits of the biosolids program will be seen. These benefits include a significant diversification of potential end uses for the biosolids including Class A and Class B land application, soil blending, fertilizer blenders, utilizing 3rd party brokers for marketing and distribution of the pellets as well as CMUD operating as a broker for uses at golf courses, sod farms and numerous other operations.

WTP Residuals Implementation Strategy: The main strategies associated with the implementation of the WTP residuals is the complete separation from the wastewater biosolids program. Some of the benefits of separating from the biosolids program include allowing for a less stringently regulated disposal of WTP residuals. WTP residuals can be treated similarly to a Class A material thereby allowing for greater flexibility in the ultimate disposal of the residuals.

As seen in **Figure ES-2**, the strategies set forth in this master plan should be re-evaluated at least every five years to assess any changes in the regulatory area or other environmental or economic changes that may influence the program.

Irwin Creek WWTP Sludge Transfer to McAlpine Creek WWMF – Avoided Costs: Prior to the recommendations in this master plan, CMUD has designed improvements to the dewatering facility at Irwin Creek WWTP including the installation of two new belt filter presses under the existing sludge storage facilities, new sludge transfer pump station, and new polymer storage and feed system with an estimated cost of approximately $2 M. Additionally, plans have been developed for a new dewatering building with a capital cost of approximately $4.5M.

As detailed in the master plan, it is recommended that unthickened primary solids and WAS be pumped to McAlpine Creek WWMF from Irwin Creek WWTP for processing and handling and that all treatment of biosolids at Irwin Creek WWTP be abandoned. In an effort to avoid the capital costs associated with dewatering improvements at Irwin Creek WWTP, it is recommended that the WAS and primary solids force mains be constructed as early as possible. It is recommended that these facilities be installed to initially transfer *anaerobically digested* biosolids from Irwin Creek WWTP to McAlpine Creek WWMF for dewatering. McAlpine Creek WWMF does not currently have the capacity in the anaerobic digesters to treat all of the unstabilized biosolids from Irwin Creek WWTP, however McAlpine Creek WWMF does have the capacity to dewater all of Irwin Creek WWTP's stabilized biosolids.

Once the THP project has been implemented (recommended completion in FY 18) then changes may be made to transfer unthickened primary solids and WAS from Irwin Creek WWTP to McAlpine Creek WWMF for stabilization. This is possible since the THP project will enable much greater capacity in the anaerobic digesters to treat additional biosolids.

Table ES-11 presents the recommended Biosolids and Residuals Master Plan implementation schedule.

2013 → 2018

ACTIONS
- Public Information Program
- Implement THP at McAlpine
- Renew Synagro contract or issue new RFP
- Evaluate dryer procurement options
- Expand NC land base
- Continue to evaluate current and emerging marketplace for end users
- Vest residuals to Franklin
- Manage WTP residuals separately from WWTP biosolids
- Irwin biosolids to McAlpine

PRODUCT END-USES
- Class B Land application
- Landfill

BENEFITS
- Address fecal regrowth/odor issues
- Increases digestion capacity
- Opportunities for regionalization
- Improved dewaterability
- Increased public acceptance and awareness
- Diversification of end uses
- Increased biogas production

2018 → 2023

ACTIONS
- Re-evaluate strategy and implementation plan
- Implement dryer at McAlpine
- Renew or issue RFP for land application

PRODUCT END-USES
- Landfill
- Class A and B cake land application
- Landfill cover
- Soil blending

BENEFITS
- Further diversification of end use
- Significant product quality improvement
- Significant reduction of product volume (20 - 30%)

2023 → 2035

ACTIONS
- Re-evaluate strategy and implementation plan
- Further develop end use options

PRODUCT END-USES
- Landfill
- Class A and B cake land application
- Landfill cover
- Soil blending
- Fertilizer blenders
- 3rd party pellet brokers
- CMUD Broker
  - Parks and Recreation
  - Golf Courses
  - Sod & Turf Farms
- Fuel source
  - Cement kiln
  - Brick kiln
  - Furnaces

Figure ES-2
Graphical Representation of the Implementation Plan

Table ES-11 CMUD Biosolids & Residuals Master Plan Implementation Schedule

Capital Project	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
WWTP Biosolids Improvement Projects												
Thermal Hydrolosis System at McAlpine												
Facilities Plan	$ 400,000											
Engineering		$ 3,650,000	$ 1,830,000	$ 1,830,000								
Construction			$ 24,700,000	$ 24,700,000								
PS & WAS Pipelines from Irwin to McAlpine												
Engineering		$ 900,000	$ 450,000	$ 450,000								
Construction			$ 6,030,000	$ 6,030,000								
Sugar & Irwin WAS Equalization Tanks at McAlpine												
Engineering		$ 65,000	$ 65,000									
Construction			$ 880,000									
Gas Conditioning System at Mallard												
Engineering			$ 85,000	$ 85,000								
Construction				$ 1,130,000								
Phosphorus Recovery at McAlpine												
Engineering				$ 385,000	$ 385,000							
Construction					$ 5,140,000							
Dewatering Complex Upgrade at McAlpine												
Engineering						$ 220,000	$ 220,000					
Construction							$ 2,970,000					
Thermal Dryer at McAlpine												
Engineering								$ 1,630,000	$ 810,000	$ 810,000		
Construction									$ 10,860,000	$ 10,860,000		
Thickening/Dewatering Improvements at Mallard												
Engineering											$ 250,000	$ 250,000
Construction												$ 3,330,000
Dewatered Residuals Storage Facility at McDowell												
Engineering											$ 380,000	$ 380,000
Construction												$ 5,170,000
WTP Residuals Improvement Projects												
Vest FM & Pump Station to Franklin												
Engineering			$ 150,000	$ 150,000								
Construction				$ 2,030,000								
Franklin Dewatered Residuals Storage Facility												
Engineering			$ 330,000	$ 330,000								
Construction				$ 4,470,000								
Duke Dewatering Building and Residuals Storage Facility												
Engineering					$ 230,000	$ 120,000	$ 120,000					
Construction						$ 1,560,000	$ 1,560,000					
Totals by FY:	**$ 400,000**	**$ 4,615,000**	**$ 34,520,000**	**$ 41,590,000**	**$ 5,755,000**	**$ 1,900,000**	**$ 4,870,000**	**$ 1,630,000**	**$ 11,670,000**	**$ 11,670,000**	**$ 630,000**	**$ 9,130,000**

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Section 1

Background and Introduction

1.1 Background

Charlotte-Mecklenburg Utilities Department (CMUD) is the largest public water and wastewater utility in the Carolinas. CMUD owns and operates five wastewater treatment plants and three water treatment plants in the City of Charlotte and greater Mecklenburg County. CMUD provides clean, safe, drinking water and wastewater services to approximately 775,000 customers. Currently, biosolids produced at CMUD's five wastewater treatment plants (WWTPs) are processed via a combination of anaerobic digestion, dewatering, land application, and landfill disposal. Water treatment plant (WTP) alum residuals from CMUD's three WTPs are dewatered and land applied.

1.2 Program Goals and Objectives

The goal of the Master Plan was established at the onset of this project and illustrated through the following mission statement:

> *The CMUD/CDM Smith team will develop a Master Plan that provides a roadmap for biosolids and residuals management that balances capital and operating/maintenance costs, benefits, and risks.*

The Master Plan demonstrates that, in pursuit of this goal, a number of objectives were achieved:

- Development of future projections for residuals characteristics and volumes.
- Evaluation of financial, environmental and social sustainability of existing dewatering operations and disposal methods.
- Identification of anticipated regulatory changes and emerging social-political issues.
- Identification of technology options for residuals treatment and handling processes.
- Determination of probable costs for feasible processing upgrades.
- Analyze the risk associated with financial, regulatory, environmental, and public relation considerations.
- Provide recommendations for a long term residuals management plan that includes a phased implementation approach.

This Biosolids and Residuals Master Plan presents the most balanced life-cycle cost-based, environmentally sound and publically acceptable approach to meet CMUD's short- and long-term residuals processing needs. CMUD intends to maintain a robust biosolids management program that is efficient and effective, provides diverse final-use/disposal outlets, and has the flexibility to adapt to changing conditions (economic, regulatory, environmental, social, technical, etc.).

Section 2

Water Treatment Plant Residuals Handling Facilities Equipment Review

A review of the performance and operation of the existing residuals processing equipment and facilities at the WTPs owned and operated by CMUD was conducted by CDM Smith personnel in June 2012.

Information for the facilities discussed in this section was obtained from site observations, review of equipment inventory provided by CMUD staff, and interviews with plant personnel. It does not include a detailed condition assessment for the residuals related equipment. A location map of the water treatment plants is shown in **Figure 2-1**. For a detailed list of the existing WTP residuals handling equipment, refer to Appendix A.

2.1 Franklin WTP Process Description

Franklin WTP is located in North Charlotte on Brookshire Boulevard and was built in 1959. Raw water from Mountain Island Lake is pumped to a reservoir located on the Franklin WTP site. The treatment process at this facility includes rapid mixing, flocculation, sedimentation, filtration, and disinfection. Chemicals used include chlorine, carbon, alum, fluoride, and lime. The facility has a rated capacity of 181 million gallons per day (mgd) and currently treats an average of 74-mgd. A simplified process flow schematic is shown in **Figure 2-2**.

2.1.1 Franklin WTP Equipment Review

Sedimentation Basin Residuals

The sedimentation basins receive raw water from Franklin WTP Reservoir. The 72-mgd east module consists of eight basins and is equipped with super scrapers for sludge collection. The 36-mgd and 24-mgd west modules, both consisting of six basins, use a chain and flight system. The solids from the sedimentation basins are conveyed to two spent wash water lagoons.

Spent Filter Backwash Water

Spent filter backwash water from 22 filters flows by gravity to the spent backwash water lagoons for flow equalization. The filters are backwashed when: turbidity reaches 0.1 NTU; the filters experience a loss of head between 6-8 feet; or every 168 hours, whichever occurs first. The backwash flow rate for filters 1 through 12 associated to the 36-mgd module ranges between 8-mgd for 2.5 minutes and 12-mgd for six minutes at the low and high wash rates. Similarly, the filter backwash flow rate for filters 13 through 22 associated to the 24-mgd and 72-mgd modules ranges between 9-mgd for three minutes and 19-mgd for nine minutes at the low and high wash rates. The resulting average backwash volume is 166,000 gallons, with five backwashes per day. The filter to waste flow rate for all filters is not measured and lasts for 15 minutes.

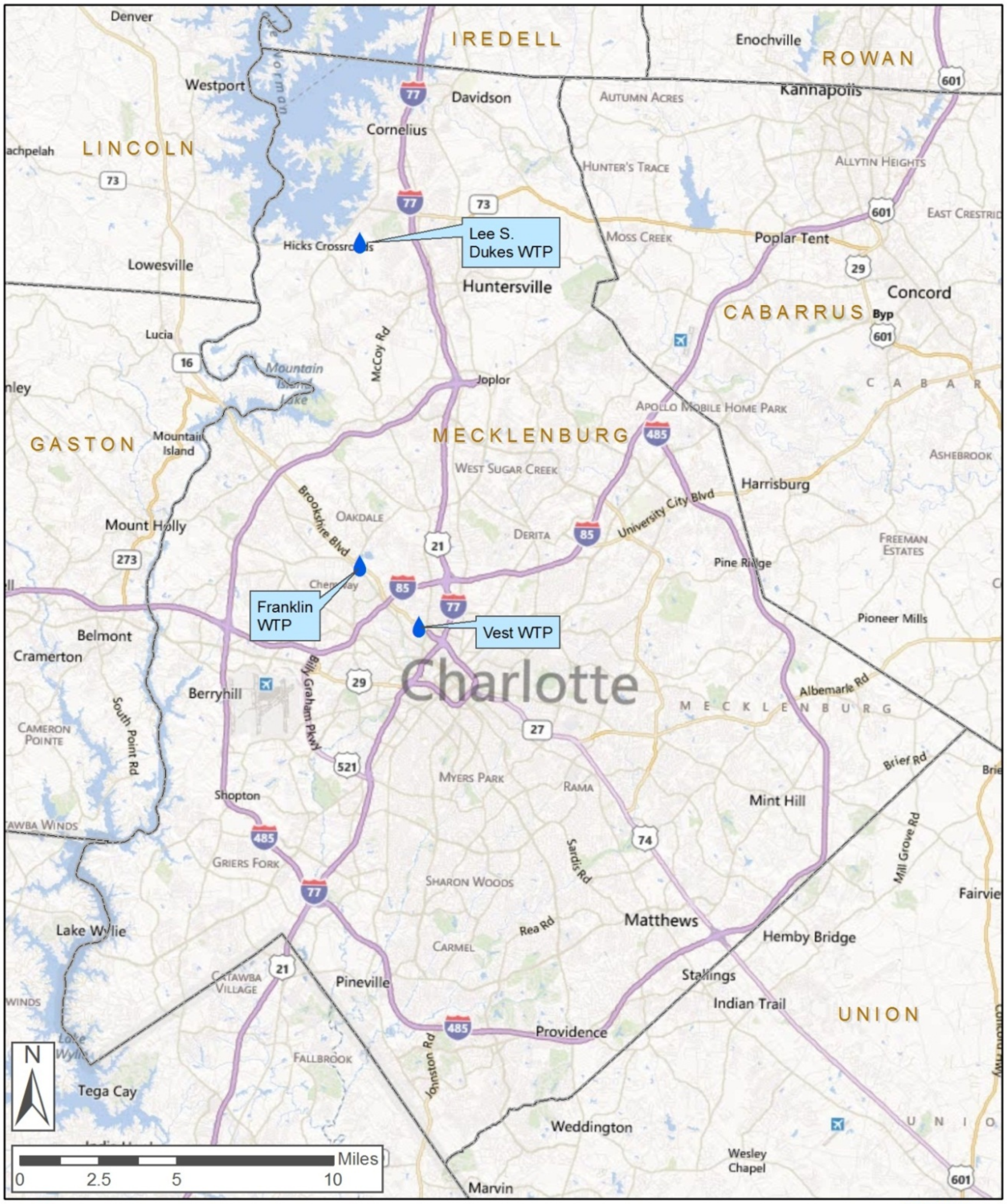

Figure 2-1
CMUD WTP Operations Location Map

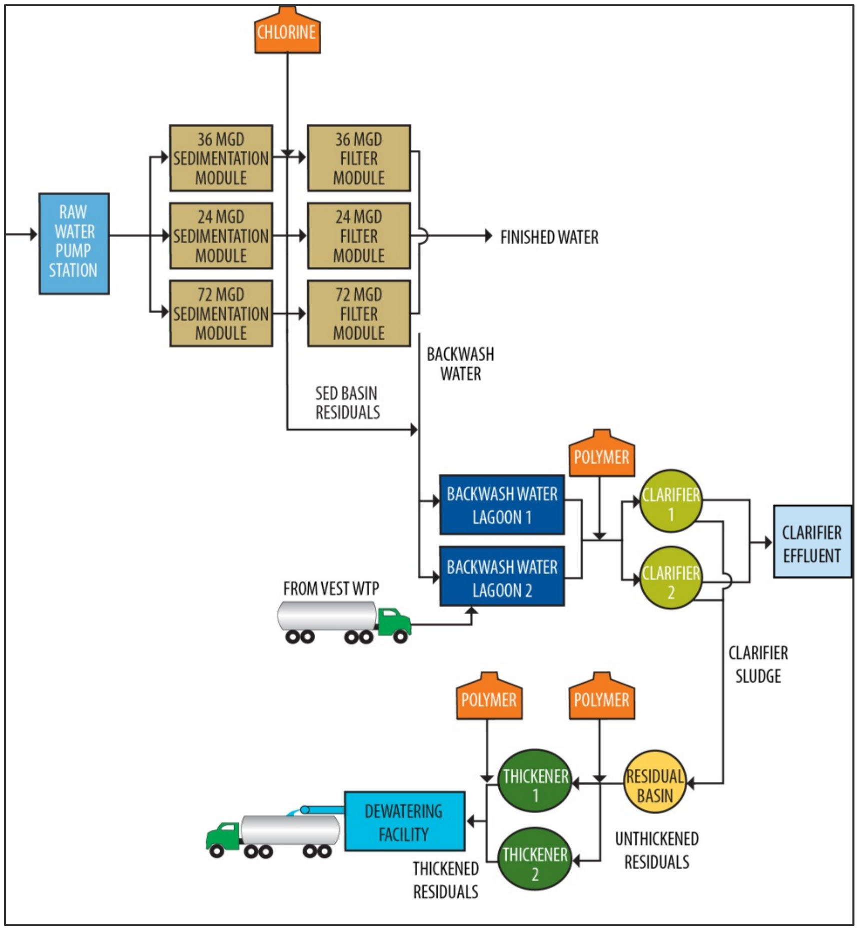

Figure 2-2
Franklin WTP Process Flow Schematic

Spent Filter Backwash Water Lagoons

All backwash water and sedimentation solids are equalized in the two lagoons with an effective capacity of 436,000 gallons and a total volume of 700,000 gallons each, as shown in **Figure 2-3**. A small amount of water from the overflow from the thickeners and press filtrate is also returned to the lagoons. When the water depth reaches 8-feet, four mixers in each lagoon are activated. The discharge from the lagoons is treated with polymer and flows by gravity to the clarifiers.

Figure 2-3
Spent Backwash Water Lagoon at Franklin WTP

Clarifiers

Flow from the spent backwash lagoons enters the splitter box where it is divided between two 70-ft and one 100-foot diameter backwash clarifiers. These clarifiers are equipped with scrapers that convey the settled residuals to the center of each tank, where they are collected into the sludge hopper. From there, the solids are pumped to the residuals basin through the three submersible pumps in the clarifier residuals pumping station. The clarifier effluent water flows over the weirs to the clarifier effluent splitter box for final discharge by gravity to an unnamed tributary to Stewart Creek. Alternatively, it is possible to discharge the effluent to the sanitary sewer, although this is not typically done. Discharge of solids from the clarifiers is typically operated manually once a week.

Residuals Basin

The residuals basin is an 85-foot diameter, 450,000 gallon holding basin where the unthickened residuals received from the clarifiers are constantly mixed for solids equalization using three submersible mixers. The residuals basin solids are discharged to one of the two gravity thickeners using two non-clog centrifugal pumps. As the solids are transferred to the thickener, they are treated with a second, larger dose of polymer.

Gravity Thickeners

One 45-foot diameter and one 55-foot diameter thickener receive the unthickened residuals from the residuals basin, at a solids concentration of approximately 1.1 percent. While one unit receives flow from the residuals basin, solids from the other tank are withdrawn and fed to the belt filter presses (BFPs). The receiving thickener is selected by the operators. The settled solids are moved by the scraper to the center of the thickeners, where they accumulate in the sludge hopper in the thickener floor. The thickened sludge at a solids concentration of 1.7 to 2.0 percent solids is withdrawn to the Dewatering Building where it is pumped to the BFPs using two progressing cavity pumps. An image of one of these gravity thickeners can be seen below in **Figure 2-4**.

Figure 2-4
Gravity Thickeners

Dewatering Facilities

From the thickeners, sludge is pumped to the dewatering system consisting of three 2-meter BFPs, **(Figure 2-5)**. The two older units, BFP 1 and BFP 2, were rebuilt in 2009 and are not typically operated. The newer unit, BFP 3, runs approximately 40 to 45 hours per week based on four 10-hour shifts, to supply a dewatered cake with a total solids concentration of 23 to 27 percent solids. Filtrate from the BFPs is conveyed back to the spent backwash water lagoons. The dewatered residuals are transported onto a belt conveyor to the Truck Loading Station from which they are hauled off-site for land application or for storage at the Irwin Creek WWTP. Current practice is to haul the solids directly to the land application sites rather than transporting them to Irwin Creek WWTP.

Figure 2-5
Dewatering Belt Filter Press

2.1.2 Franklin WTP Operational Constraints

Truck Loading Station

The existing truck loading station has a single discharge point. Dump trucks need to be repositioned twice under the hopper for proper collection of the dewatered cake. This operation takes approximately four hours in order to fill 20-tons of dewatered residuals on each truck and occurs on a four to five days per week schedule. The current contract hauler (Synagro) provides a permanent tractor on-site for moving and positioning the trailers.

Unthickened Residuals Pump Station

- Accumulating solids in pipe short runs: The three unthickened residuals pumps are connected to a common header. Normally one pump is in service. As the unthickened residuals are pumped through one pump to the thickeners, some residuals solids and other grit-type debris can accumulate in the other two pumps' short run pipes. These materials, if left in the short runs, could accumulate enough to prevent a pump from discharging. In order to prevent the materials from accumulating enough to cause a problem, the pumps need to be rotated frequently.

- Impeller damage: The unthickened residuals that are pumped to the thickeners include sand and other grit that travel through the system; there may also be larger pieces of material, i.e., small chunks of concrete, rocks, and shells. These can cause wear on the impeller.

2.2 Vest WTP Process Description

The Vest WTP, located on W. Brookshire Freeway north of Uptown Charlotte, was built in the 1920s making it Charlotte's oldest water treatment facility. Water from Mountain Island Lake is pumped from the Catawba River Pump Station to three reservoirs at the Franklin WTP. The raw water is then gravity-fed to both the Franklin WTP and to the Vest WTP. The Vest WTP is a conventional surface water treatment plant, employing flocculation, sedimentation, filtration, and disinfection processes. The plant has a rated capacity of 32.0-mgd, but it is hydraulically limited to an available capacity of 24-mgd. Since 2009, the plant has treated an average of 14.8 mgd. A simplified process flow schematic is shown in **Figure 2-6**.

Sedimentation Residuals

Sedimentation basins provide an environment for the floc to settle out of the flow, reducing the settled water turbidity to a target at or below 1.0 NTU prior to flowing into the filters. The eight sedimentation basins at the Vest WTP are equipped with submerged collectors to remove settled solids at the bottom of the basins. This system consists of a trac-vac system driven with compressed air, with the direction of travel east and west along the basin floor. The trac-vac system is programmed to remove 155 gallons per minute (gpm) for 160 minutes per day for a total of 25,000 gallons per day.

The north basins (Basin 1 through Basin 4) are equipped with three collectors, and the south basins (Basin 5 through Basin 8) with two collectors each. The collectors are programmed to start at timed intervals and operate in automatic mode. From the collectors, the residuals are transported through flexible hoses to a fixed pipe header located in the basin, and from there to the unthickened residuals pump station. Settled water leaves the sedimentation basins through troughs which collect the settled water from the each basin and convey it to the filter influent channel.

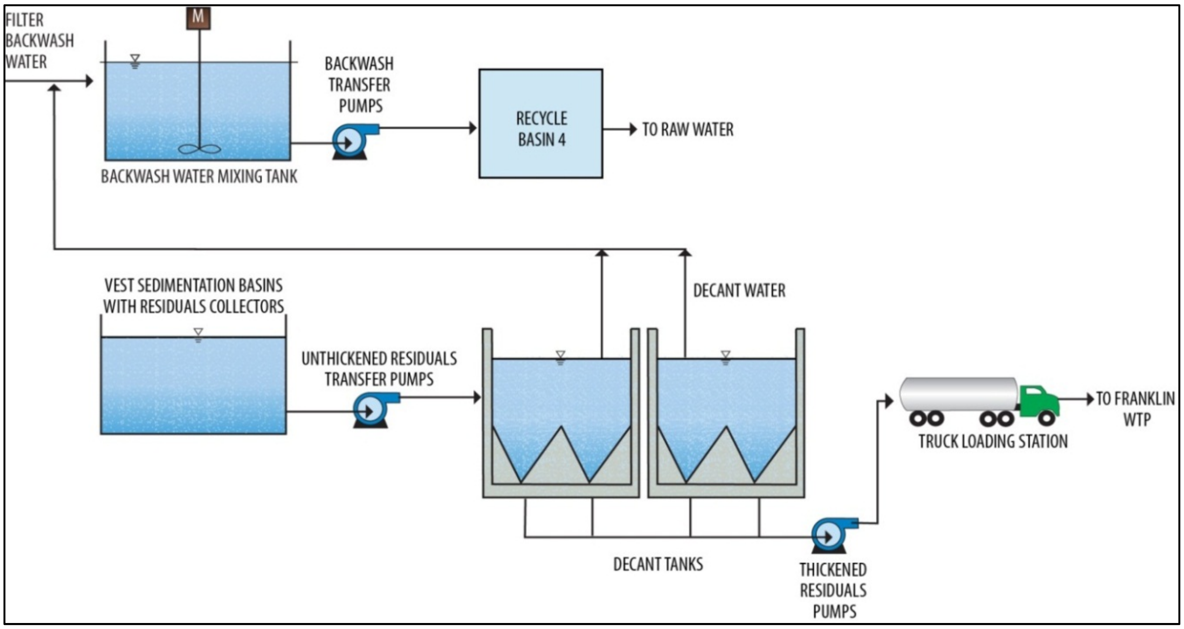

Figure 2-6
Vest WTP Process Flow Schematic

Spent Filter Backwash Water

Spent Backwash water from six 40-feet by 12-foot filters and six 56-feet by 17-foot filters flow by gravity to a backwash water mixing tank. The filters are backwashed when: turbidity reaches 0.1 NTU; the filters experience a loss of head between 6-8 feet; or every 168 hours, whichever occurs first.

The filter backwash flow rate ranges between 4,500 and 8,000 gpm, with a duration of three minutes each for filters one through six, and six minutes each for filters seven through twelve with a resulting average backwash volume of 95,000 gallons. After backwash, and during the ripening period, the filter-to-waste (FTW) flow rate is approximately 5,000 gpm for filters one through six and 11,000 gpm for filters seven through twelve, and the FTW duration is estimated at 15 minutes.

Unthickened Residuals Pump Station

The unthickened residuals pump station, shown in **Figure 2-7,** conveys residuals from the sedimentation basins collector system to the decant tanks through three horizontal, non-clog centrifugal pumps.

Figure 2-7
Vest WTP Unthickened Residuals Pump

Residuals Decant Tanks

The two 90,000 gal decant tanks **(Figure 2-8)** allow thickening of the residuals from two to four percent solids by decanting the supernatant from the settled residuals. Decant flows by gravity to the backwash water mixing tank. Residuals from the decant tanks are pumped to a tanker truck and transported to the Franklin WTP for disposal. On average, this operation corresponds to ten truckloads of approximately 6,400 gallons each per week.

Thickened Residuals Pump Station

The Thickened Residuals Pump Station is equipped with two dry-pit constant speed, self-priming pumps that are used to pump the settled solids in the decant tanks to the adjacent truck loading station.

Thickened Residuals Truck Loading Station

The loading station allows hauling liquid sludge with tanker trucks to the Franklin WTP for processing. Polymer addition is available but is not typically used.

Backwash Water Mixing Basin

The backwash water mixing basin is a 70-foot diameter circular tank equipped with three submersible mixers to keep the solids in suspension. Three submersible transfer pumps discharge from the backwash water mixing basin to Recycle Basin 4 to be recycled back to the head of the plant.

Figure 2-8
Vest Decant Tank

2.2.1 Vest WTP Operational Issues and Constraints

Sedimentation Basins

- Trac-vacs do not operate properly (especially for the older filters) and require substantial maintenance. One of the issues is related to moisture in the pneumatic system affecting solenoid valves functioning.
- Sand accumulates in sedimentation basins and cannot be easily removed by trac-vacs.
- Replacement of trac-vacs with other sludge collectors should be considered.

Decant Tanks

The decant tanks can only decant at three pre-set levels. Telescopic valves or other means to allow decanting at multiple water levels from the decant tanks should be considered.

Backwash Water Mixing Tank

Sediments and sand in the backwash water mixing basin can only be removed from the top of the tank. As an alternative, the sediments could be conveyed using the new wastewater pumps to the truck loading station. This would require replacing the existing 90-degree elbow in the pump discharge and add piping to truck loading station.

2.3 Lee S. Dukes WTP Process Description

Lee S. Dukes Jr. WTP, located in Huntersville began operations in 1998 and serves pressure zone 978. The facility consists of a conventional surface water treatment process employing flocculation, sedimentation, filtration, and disinfection processes. Raw water from Lake Norman flows by gravity to the WTP, where it is treated with powdered activated carbon (PAC), alum, and potassium permanganate before entering two sedimentation basins. Fluoride and lime are added to finished water before it is distributed between three, 9 million gallon clearwells. Chlorine can be either added before or after the sedimentation modules, or downstream of the filters. Lee S. Dukes WTP has a capacity of 25.3-mgd and the current average raw water treated is approximately 16-mgd. A simplified process flow schematic is shown in **Figure 2-9**.

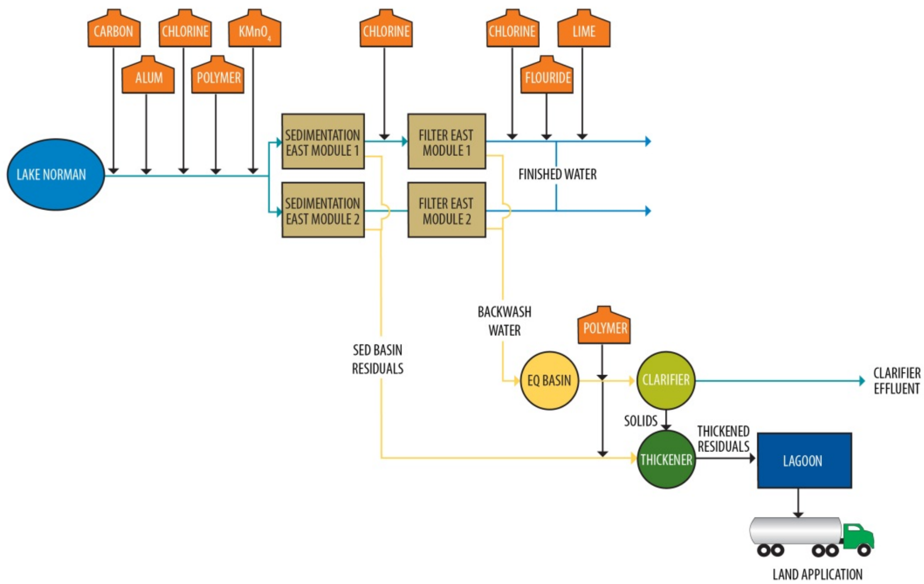

Figure 2-9
Lee S. Dukes WTP Process Flow Schematic

2.3.1 Lee S. Dukes WTP Equipment Review

Sedimentation Residuals

Residuals from two sedimentation basins (East Module 1 and East Module 2) are removed using chain and flight type collectors. These collector mechanisms were replaced recently, due to damage caused by chlorinated water to the previous units. Approximately every two hours, a residuals drain (blow-down) valve in each basin is actuated to convey the sludge by gravity into a residuals flow splitter well prior to discharge to the residuals thickener. Below a pre-set water level in the sedimentation basins, the residuals are pumped into the well by two horizontal dry-pit solids-handling pumps. The valves are set to have 16 blow-downs per day of approximately one minute each, discharging solids at concentration of 0.5 to 1.0 percent solids. A photograph of the existing sedimentation basins is shown in **Figure 2-10**.

Figure 2-10
Lee S. Dukes WTP Sedimentation Basins

Filter Backwash Residuals

Backwash water from two filter modules (East Module 1 and East Module 2, consisting of two filters each) flows by gravity to the wash water equalization basin. The filters are backwashed when: turbidity reaches 0.1 NTU; the filters experience a loss of head between 6-8 feet; or every 168 hours, whichever occurs first. Filter backwash flow rate is approximately 15,000 gpm with a duration of 10 minutes each. The resulting average backwash is 143,000 gallons, with 1 backwash per day. The filter to waste flow rate is in the range of 1,500 to 4,300 gpm, with a duration of approximately 15 minutes.

Wash Water Equalization Basin

The 85-foot diameter wash water equalization basin is equipped with three mixers. From there, flow is discharged by three submersible centrifugal transfer pumps to the wash water clarifier, which is positioned at higher elevation. A photograph of the existing washwater equalization basin is shown in **Figure 2-11**.

Wash Water Clarifier Basin

The 85-foot diameter wash water clarifier basin is equipped with a residuals collector system. The overflow from the clarifier is conveyed to the de-chlorination structure, where sodium bisulfite is added prior to discharge into McDowell Creek, while the solids underflow is discharged to the thickener by opening a blow down valve.

Figure 2-11
Lee S. Dukes WTP Equalization Basin

Residuals Thickener

The 50-foot diameter gravity thickener has a circular collector and receives solids from the wash water clarifier and from the sedimentation basins. The thickened residuals at a solids concentration of 1 to 1.5 percent solids are discharged by gravity to the lagoon every six to eight hours. Two horizontal end suction centrifugal pumps in the Thickened Residuals Pump Station have the ability to transfer the solids in the thickener to the truck loading station adjacent to the thickener. However, the capacity of these pumps is considered insufficient and the truck loading station is not typically used by CMUD.

Thickened Residuals Storage Lagoon

The 212 foot by 97-foot rectangular lagoon has a storage capacity of approximately 1 million gallons, sufficient to store approximately three to four months of current sludge production **(Figure 2-12)**. Decant from the lagoon can be discharged to a permitted discharge point or to the sewer system (although the latter alternative is not practiced). The solids from the lagoon can reach three to four percent solids concentration and are pumped onto trucks and land applied. Trucks can also be loaded from the thickener, but this practice has been discontinued in recent years.

Figure 2-12
Lee S. Dukes WTP Thickened Residuals Storage Lagoon

2.3.2 Lee S. Dukes WTP Operational Constraints

Lagoon

There is only one lagoon requiring solids removal three to four times per year. An increase in storage capacity would allow less frequent hauling requirements.

Dewatering Operations

Adding a belt filter press (BFP) or other dewatering equipment at this facility would alleviate dependence on liquid storage. A dewatering facility would need to be constructed to house the BFP.

Equalization Basin

Recycle of the decant from the dechlorination contact chamber to the head of the WTP may be considered. A new pump station would be required for this purpose.

Section 3

Water Treatment Plant Residuals Production

3.1 Background

This section evaluates historic and projected water supply and residuals production for the three water treatment plants (WTPs) owned and operated by Charlotte-Mecklenburg Utility Department (CMUD) up to year 2035. The projections were based on the following sources:

- Water System Master Plan (Black and Veatch, 2008) (2008 MP)
- Historical daily data collected between 2009 and 2011
- Feedback provided by CMUD staff during Workshop 1

Franklin, Vest, and Lee S. Dukes WTPs employ a conventional treatment process of alum-coagulation, sedimentation, filtration, and disinfection. Residuals management differs for each plant and is described in detail in Section 2.

CMUD's water service area is divided into three pressure zones: Zone 882, Zone 960, and Zone 978. Water demand in Zones 882 and 960 is serviced by a combination of Franklin WTP and Vest WTP, while Zone 978 is serviced by Lee S. Dukes WTP. Flow transfer between pressure zones is, however, possible through interconnects in the distribution piping. The existing capacities of the WTPs are summarized in **Table 3-1.**

Table 3-1 WTP Capacity

WTP	Existing Treatment Capacity (mgd)
Franklin	181*
Vest	36*
Lee S. Dukes	25.3

* *Due to raw water intake hydraulic limitations, capacity of Vest WTP is limited to 24 mgd. Discharge head constraints limit the maximum pumping capacity at Franklin WTP to 120 mgd.*

3.1.1 Review of Previous Reports

In order to develop projections of residuals production, available studies identifying water projections in CMUD's service area for the 20-year planning period were reviewed. The 2008 MP presents the most recent water supply projections by pressure zone, as summarized in **Table 3-2**, and was used as a reference for this analysis. Since water demand projections for individual WTPs were not provided, it was assumed that the combined demand in Zones 882 and 960 will be supplied entirely by Franklin WTP and Vest WTP, while the demand in Zone 978 will be supplied entirely by Lee S. Dukes WTP.

Table 3-2 Water Supply Projections in the 2008 Master Plan

Year	Annual Average Water Supply Demand (mgd)				
	Zone 882	Zone 960	Total (882 + 960)	Zone 978	Total System
2015	95.6	18.9	114.6	28.7	143.3
2020	104.3	21.4	125.7	32.5	158.2
2025	113.0	23.8	136.8	36.4	173.2
2030	121.7	26.2	147.9	40.3	188.2
2035	130.4	28.7	159.0	44.1	203.1

From a review of these projections against the historical records from year 2009 to year 2011 (see **Table 3-3**), it is evident that the observed flows have not grown as aggressively as forecasted by the 2008 MP.

Table 3-3 Comparison of Observed Versus Projected System-Wide Water Supply Demand

Year	System-Wide Annual Average Water Supply Demand (mgd)	
	2008 MP Projection	Actual
2009	124.4	100.7
2010	127.6	115.9
2011	130.7	103.8

The preliminary approach used to avoid overestimating water projections consisted of shifting the original projections in the 2008 MP forward in time to intersect historical flows, while maintaining the same growth pattern. For the system-wide water supply, this corresponded to a two percent annual rate of increase, reaching 177 mgd of annual average in year 2035. This method resulted in a two percent annual growth for Franklin WTP and Vest WTP and a 3.2 percent annual growth for Lee S. Dukes WTP.

Current CMUD revenue projections anticipate a 0.5% annual increase for the next ten years, necessitating a revision of the projections to reflect the trend as forecasted by CMUD. For Franklin WTP and Lee S. Dukes WTP, a cone of projections was developed, in which the envelope of conditions is represented by an 'aggressive' growth closer to the 2008 MP forecast, and by a 'moderate' growth trend consistent with current revenue trends. For Vest WTP, a projection based on CMUD's anticipated expansions at this facility was used.

3.2 Historical and Projected Water Supply

3.2.1 Franklin WTP

Franklin WTP annual average water supply projections were enveloped between a 'moderate' growth and an 'aggressive' growth curve up to year 2035, as shown in **Figure 3-1** and summarized in **Table 3-4**.

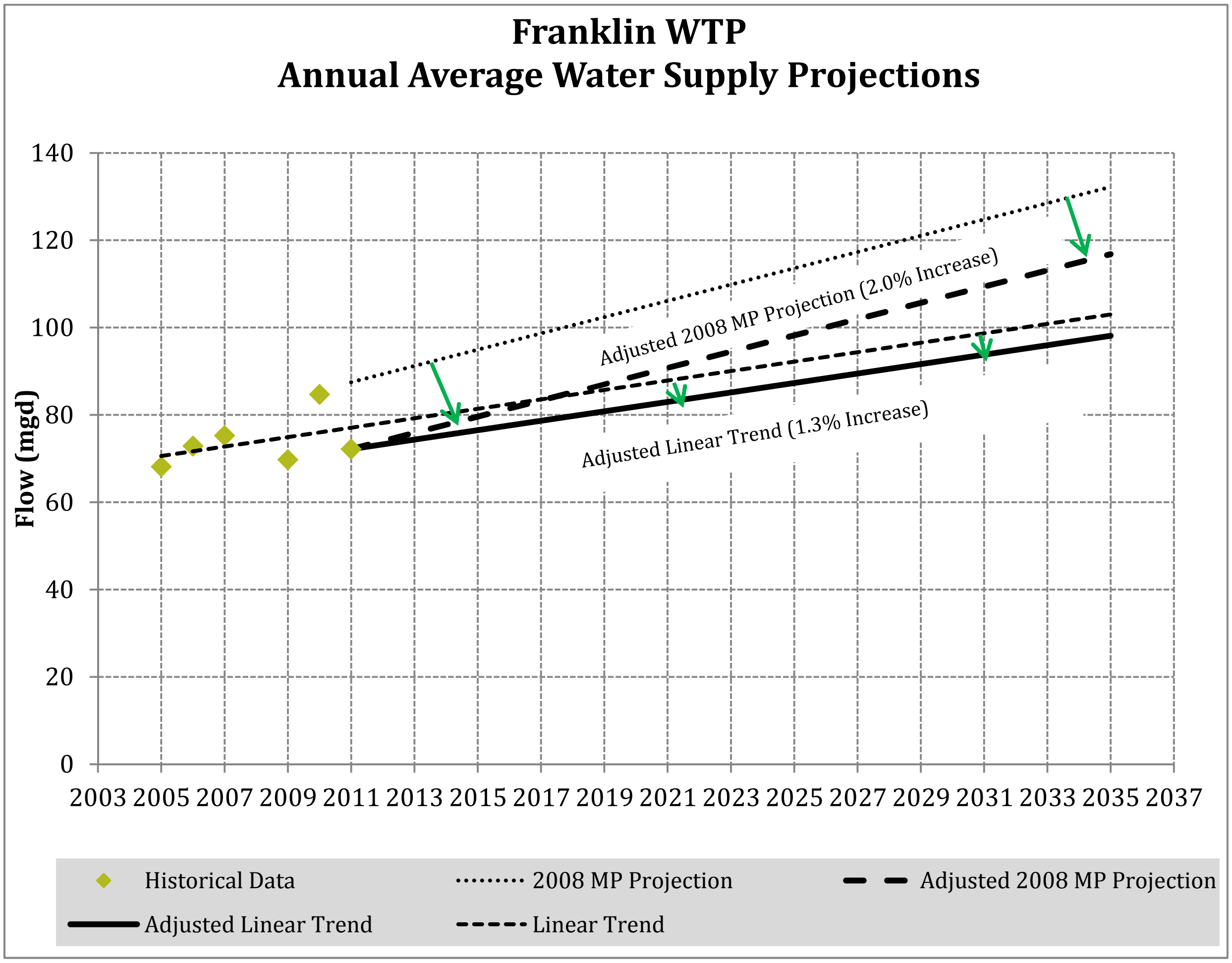

Figure 3-1
Franklin WTP – Annual Average Water Supply Projections

The 'moderate' growth projection consists of a linear trend line of the historical data from year 2005 to year 2011. It was shifted forward in time to intersect the water supply measured in year 2011 and presents a 1.3 percent rate of annual increase.

The 'aggressive' growth projection maintains the same growth pattern estimated in the 2008 MP, representing approximately a two percent rate of annual increase, but shifted forward in time to intersect historical flows.

Table 3-4 Franklin WTP – Annual Average Water Supply

Year	Franklin WTP Annual Average Water Supply (mgd)	
	1.3% Increase	2.0% increase
2015	76.5	79.6
2020	81.9	88.9
2025	87.3	98.2
2030	92.7	107.5
2035	98.1	116.8

3.2.2 Vest WTP

CMUD anticipates that Vest WTP will treat 19-mgd for the next decade (between year 2013 and year 2023) after which point miscellaneous process and hydraulic upgrades will be completed. From year 2023, it is estimated that this facility will treat 24-mgd for the remainder of the planning period. Vest WTP water supply projections are summarized in **Figure 3-2** and **Table 3-5.**

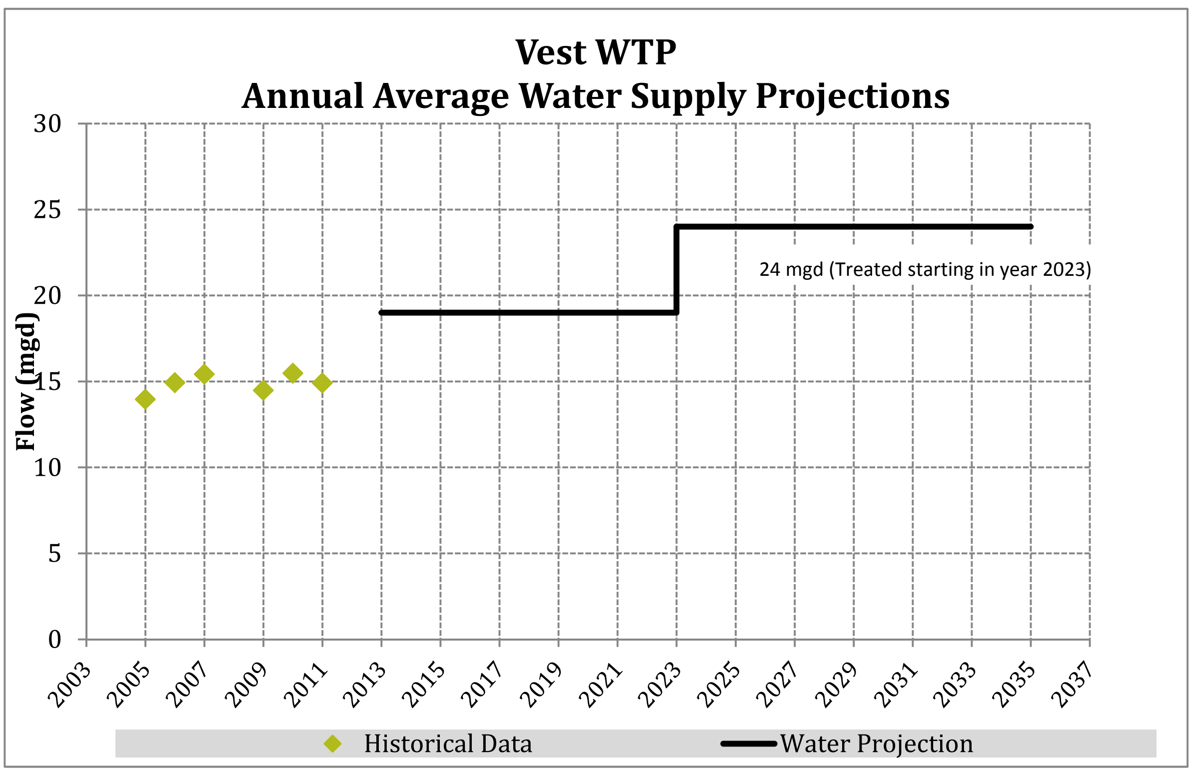

Figure 3-2
Vest WTP – Annual Average Water Supply

Table 3-5 Vest WTP – Annual Average Water Supply

Year	Vest WTP Annual Average Water Supply (mgd)
2015	19.0
2020	19.0
2025	24.0
2030	24.0
2035	24.0

3.2.3 Lee S. Dukes WTP

Lee S. Dukes WTP annual average water supply projections were enveloped between a 'moderate' and an 'aggressive' growth curve up to year 2035 as shown in **Figure 3-3** and summarized in **Table 3-6**.

- The 'moderate' growth projection consists of a linear projection with a 0.5 percent rate of annual increase.
- The 'aggressive' growth projection presents a 1.5 percent rate of annual increase.

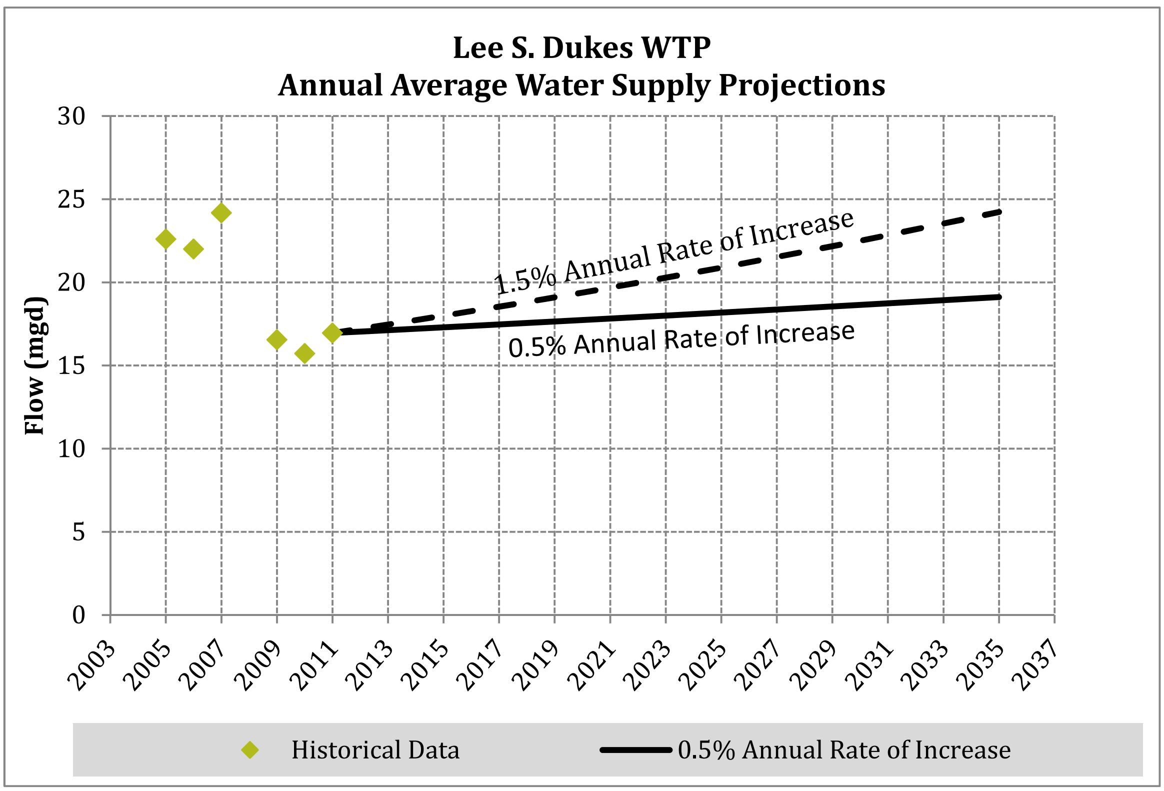

Figure 3-3
Lee S. Dukes WTP – Annual Average Water Supply Projections

Table 3-6 Lee S. Dukes WTP – Annual Average Water Supply

Year	Lee S. Dukes WTP Annual Average Water Supply (mgd)	
	1.5% Increase	0.5% increase
2015	17.3	18.0
2020	17.7	19.4
2025	18.2	20.9
2030	18.6	22.5
2035	19.1	24.2

3.3 Historical and Projected Residuals Production Rates

3.3.1 Historical WTP Operating Data

Historical records for all WTPs were obtained from CMUD for the period between January 2009 and June 2012. As summarized in **Table 3-7**, these data included daily raw water characteristics, flow rate, and chemical feed dosage and were used to quantify historical and projected residuals up to year 2035.

Table 3-7 Historical Raw Water Characteristics (January 2009 – June 2012)

	Raw flow (mgd)	Raw turbidity (NTU)	Coagulant dose (mg/L)	KMnO4 dose (mg/L)	PAC dose (mg/L)	Estimated Residuals (Dry Ton per Day)	Estimated Residuals (Dry Ton per Mgal)
Franklin WTP							
Average	73.7	4.2	13.4	-	1.7	4.24	0.06
Max Month	110.6	10.0	16.0	-	4.2	5.74	0.08
Peak Factor	1.51	2.4	1.2	-	2.5	1.36	
Vest WTP							
Average	15.0	4.2	10.2	-	1.6	0.79	0.05
Max Month	21.5	9.7	13.4	-	4.3	1.12	0.07
Peak Factor	1.45	2.3	1.3	-	2.6	1.43	
Lee S. Dukes WTP							
Average	16.3	2.0	11.2	0.11	2.5	0.71	0.04
Max Month	22.5	5.3	12.8	0.11	5.1	0.93	0.06
Peak Factor	1.38	2.7	1.1	1.0	2.1	1.31	

3.3.2 Estimation of Residuals Production

In order to quantify alum residuals, the following empirical formula is commonly utilized in the water industry (AWWA, 1999).

S = 8.34 * Q (0.44 *Alum + Tu * b + A)

where: S = Residuals produced (dry lb/day)

Q = Raw water flow (mgd)

Al = Dry alum dose (17.2% Al_2O_3, 9.1% Al)

Tu = Raw Turbidity (NTU)

A = PAC and/or $KMnO_4$ (mg/L as dry product)

b = Ratio of total suspended solids (TSS) / turbidity

The "b" value in the equation represents a correlation between raw water turbidity and TSS and for most WTPs it ranges from 0.7 to 2.2. In the absence of historical data, a value of 1.5 was assigned to "b".

In combination with plant data, this empirical formula was used to estimate the historical production of residuals generated on a daily basis. As summarized in **Table 3-8**, the results were also presented in terms of dry tons generated per million gallon of raw water treated.

Table 3-8 further compares the estimated historic residuals production against the measured quantity of solids disposed of by Synagro over the same period of time. Synagro's reports were expressed in wet tons per day for the dewatered cake at Franklin WTP and in gallons per day for the liquid sludge hauled at Vest WTP and land applied at Lee S. Dukes WTP.

The estimated residuals production obtained using the model discussed above compares favorably with the measured data for Franklin WTP and Vest WTP plants. The estimated solids for Lee S. Dukes WTP overestimate the measured liquid sludge land applied by Synagro. The calculations would require assuming a solids concentration of 4.5 percent solids, instead of 3.5 percent solids, in order to match the measured quantities. The estimated residuals production was not varied as a conservative approach.

Table 3-8 2009-2011 Residuals Production (Measured vs. Estimated)

	Measured	Estimated
Franklin WTP		
Wet Tons per Day (at 25% Solids Concentration)	19.7	20.1
Vest WTP		
Gallons per Day (at 2% Solids Concentration)	9,000	9,400
Lee S. Dukes WTP		
Gallons per Day (at 3.5% Solids Concentration)	3,700	4,900

3.3.3 Future Residuals Production

Future residuals production was calculated multiplying residuals estimates at each plant (in dry tons per million gallon of raw water treated) by projected water demand up to year 2035. As shown in **Table 3-9** and **Table 3-11** for Franklin WTP and Lee S. Dukes WTP, the cone of water projections developed for these plants resulted in an envelope of residuals quantities represented by an 'aggressive' growth on the high end, and by a 'moderate' growth trend on the low end (the latter being consistent with current revenue trends). For Vest WTP, a projection based on CMUD's anticipated expansions at this facility was used (see **Table 3-10**).

All quantities are expressed in terms of mass of dry solids (rather than wet volume), as this is not affected by the specific thickening and dewatering operations, and their respective reduction in volume of the material handled.

Table 3-9 Franklin WTP – Future Residuals Production

Year	Annual Average Raw Water Flow (mgd)		Annual Average Residuals Production (Dry Tons per Day)		Max Month Residuals Production (Dry Tons per Day)	
	Moderate Growth	Aggressive Growth	Moderate Growth	Aggressive Growth	Moderate Growth	Aggressive Growth
2015	76.5	78.1	4.4	4.5	6.0	6.1
2020	81.9	86.3	4.7	5.0	6.4	6.7
2025	87.0	95.2	5.0	5.5	6.8	7.4
2030	92.7	105.1	5.3	6.0	7.2	8.2
2035	98.1	116.1	5.6	6.7	7.6	9.0

Notes: Excludes residuals production generated at Vest WTP and processed at Franklin WTP

Table 3-10 Vest WTP – Future Residuals Production

Year	Annual Average Raw Water Flow (mgd)	Annual Average Residuals Production (Dry Tons per Day)	Max Month Residuals Production (Dry Tons per Day)
2015	19.0	1.0	1.4
2020	19.0	1.0	1.4
2025	24.0	1.2	1.8
2030	24.0	1.2	1.8
2035	24.0	1.2	1.8

Table 3-11 Lee S. Dukes WTP – Future Residuals Production

Year	Annual Average Raw Water Flow (mgd)		Annual Average Residuals Production (Dry Tons per Day)		Max Month Residuals Production (Dry Tons per Day)	
	Moderate Growth	Aggressive Growth	Moderate Growth	Aggressive Growth	Moderate Growth	Aggressive Growth
2015	17.3	18.0	0.7	0.8	1.0	1.0
2020	17.7	19.4	0.8	0.8	1.0	1.1
2025	18.2	20.9	0.8	0.9	1.0	1.2
2030	18.6	22.5	0.8	1.0	1.0	1.3
2035	19.1	24.2	0.8	1.0	1.1	1.3

Since equipment processing capacity is typically based on maximum month conditions, the projected maximum month residuals are also provided graphically in **Figures 3-4** through **3-6** for each WTP.

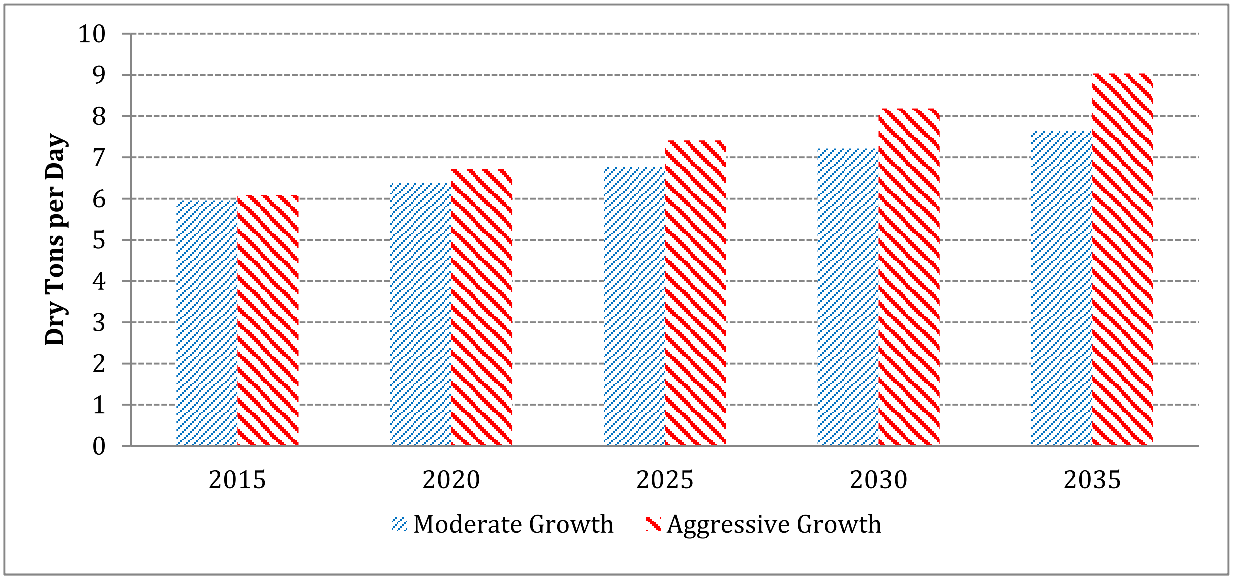

Figure 3-4
Franklin WTP – Future Residuals Production (Max Month Conditions)

The difference between aggressive and moderate growth is relatively modest, resulting in 1.4 dry tons per day at Franklin WTP in year 2035. Given the level of uncertainty involved in raw water projections, the use of empirical equations to forecast solids, and the limited impact on process sizing of the use of either growth model, it is prudent to use the 'aggressive growth' scenario instead of the 'moderate growth scenario' for Franklin WTP and Lee S. Dukes WTP.

The recommended basis of design for solids handling equipment for future conditions is therefore summarized in **Table 3-12**.

Table 3-12 WTP Residuals – Basis of Design

Year	Max Month Residuals Production (Dry Tons per Day)			
	Franklin WTP	Vest WTP	Lee S. Dukes WTP	Total
2015	6.1	1.4	1.0	8.5
2020	6.7	1.4	1.1	9.2
2025	7.4	1.8	1.2	10.4
2030	8.2	1.8	1.3	11.3
2035	9.0	1.8	1.3	12.1

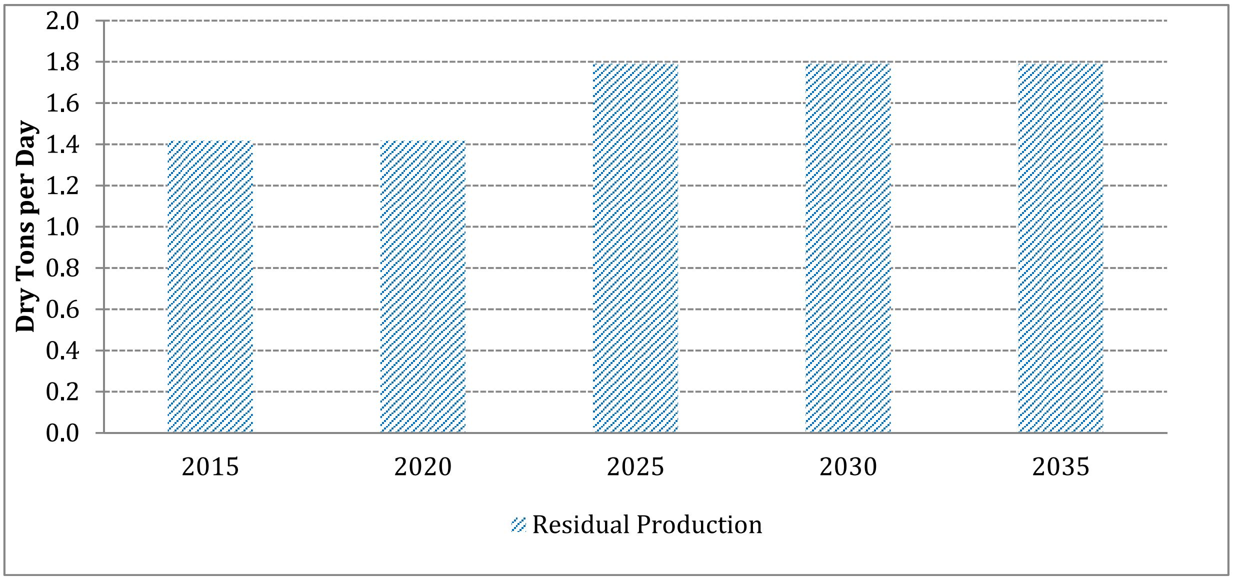

Figure 3-5
Vest WTP – Future Residuals Production (Max Month Conditions)

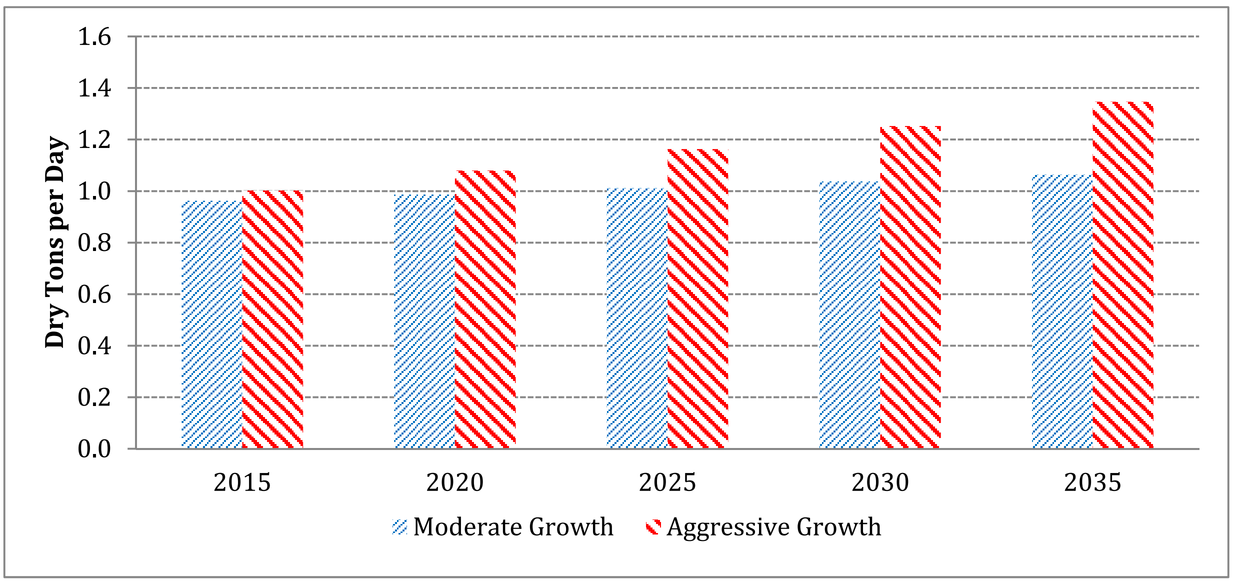

Figure 3-6
Lee S. Dukes WTP – Future Residuals Production (Max Month Conditions)

Section 4

Biosolids Handling Facilities Equipment Review

A review of the performance and operation of the existing biosolids handling equipment and facilities at the wastewater treatment plants (WWTPs) owned and operated by Charlotte-Mecklenburg Utility Department (CMUD) was conducted by CDM Smith personnel in June 2012.

Information for the facilities discussed in this section was obtained from site observations, review of equipment inventory provided by CMUD staff, and interviews with plant personnel. It does not include a detailed condition assessment for biosolids and residuals related equipment. Appendix B includes a summary of the main equipment at these facilities and a location map is shown in **Figure 4-1**.

4.1 McAlpine Creek WWMF Process Description

McAlpine Creek Wastewater Management Facility (WWMF) represents the largest facility owned and operated by CMUD. The original plant was built in 1966 in Pineville, NC and discharges into McAlpine Creek WWMF. In the years since, multiple improvements and capacity expansions have occurred. The plant is currently permitted for a treatment capacity of 64-mgd and the current average flow rate through the plant is approximately 44-mgd. A simplified process flow schematic is shown in **Figure 4-2**.

The McAlpine Creek WWMF consists of two separate primary and secondary trains, the North Plant and the South Plant. Both treatment trains have similar processes, including primary sedimentation, secondary treatment and clarification, with combined tertiary filtration and disinfection. Primary sludge and waste activated sludge (WAS) generated at Sugar Creek WWTP are also conveyed to this plant for treatment.

Primary Sludge

Primary sludge from four 130-foot diameter primary clarifiers at the North Plant is gravity fed to a gravity thickening system, while the primary sludge from four 125-foot diameter south primary clarifiers is pumped using chopper pumps to the same thickening system. Primary sludge from the Sugar Creek WWTP combines with the primary sludge from McAlpine Creek WWMF at the first stage of the gravity thickening system, primary sludge screening and flow splitting facility. The combined sludge is screened through a ¼ in. mechanically cleaned screen and sent to a splitter box from where it is split between four gravity thickeners.

The two newer north primary clarifiers can be served by a sludge pumping station which has however never been used to date. The north primary clarifiers also have the capability to thicken although the plant has never operated them in this mode. Problems with clogging have been reported in the new north primary sludge transfer piping due to excessive debris. This is generally controlled by maintaining primary sludge concentrations in the range of 0.5 percent solids. The solids concentration of the combined North Plant and South Plant primary sludge is approximately 0.5 percent solids.

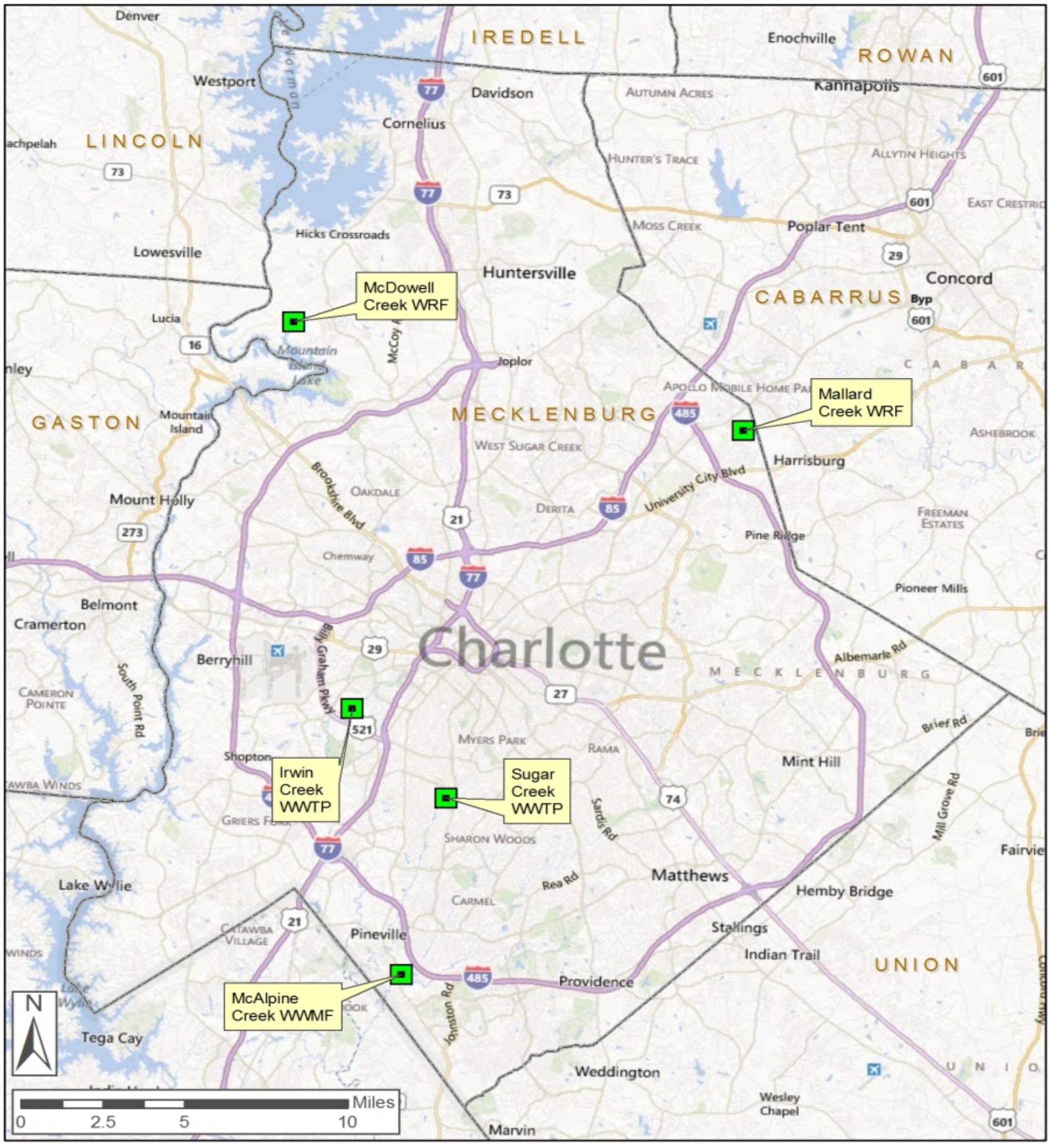

Figure 4-1
CMUD Operations Location Map

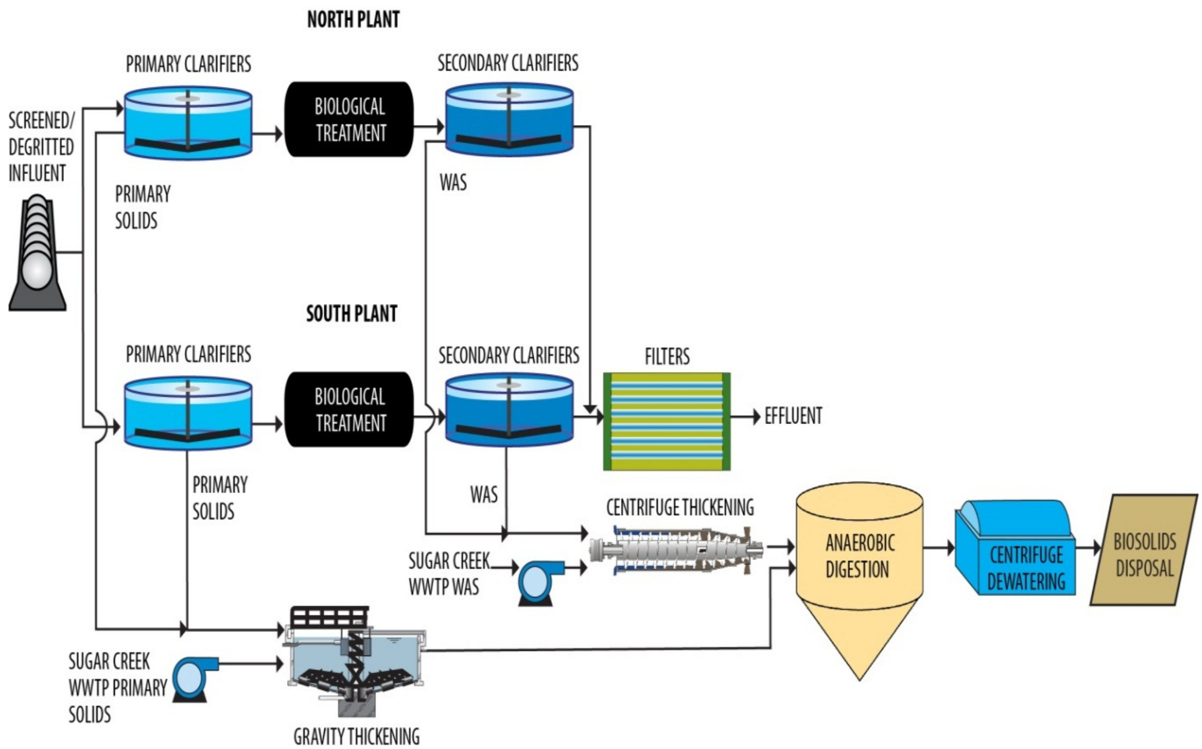

Figure 4-2
McAlpine Creek WWMF Process Flow Schematic

Chemically enhanced primary treatment (CEPT) is an optional treatment system available at McAlpine Creek WWMF. It was originally designed for use as the flows and loads at the plant increased to near design capacity (55-mgd or greater) under winter temperature conditions to maintain nitrification capacity. To date, this system has not been utilized, although it does present opportunities for enhancing primary sludge production, which would affect liquid and solids treatment train performance, biosolids production and processing, and energy generation.

Secondary Sludge

The North Plant has four 95-foot diameter and two 125-foot diameter secondary clarifiers, while the South Plant has four 95-foot diameter, four 105-foot diameter and two 125-foot diameter secondary clarifiers. Five RAS/WAS Pump Stations are associated with the secondary clarifiers. Sludge cannot be wasted from RAS Pump Station No. 1 (which collects sludge from secondary clarifiers 1 and 2), nor from RAS Pump Station No. 4 (which collects sludge from secondary clarifiers 11, 12, 13, and 14). RAS Pump Stations No. 2, 3, and 5 receive secondary sludge from the remaining clarifiers and have both RAS and WAS capabilities. All WAS from these pump stations, in addition to WAS transferred from Sugar Creek WWTP and the scum from the gravity thickeners, is conveyed to the WAS pump station wet well. The total wasting time typically averages 21 to 22 hours per day with the thickening feed pumps and the centrifuges running the entire wasting cycle.

Figure 4-3
WAS Pump for Thickening Centrifuge

Gravity Thickening

Primary sludge from the North and South process trains, in addition to primary sludge from Sugar Creek WWTP, is thickened in two 45-foot diameter and two 60-foot diameter gravity thickeners. The effluent from the gravity thickeners flows to a wet well at the Gravity Thickener Effluent Pump Station. From there, the flow is pumped to the north and south plants where it mixes with return activated sludge (RAS) and primary clarifier effluent and flows into the aeration basins.

The thickened primary sludge is pumped to the anaerobic digesters from dedicated pump stations at each of the two sets of gravity thickeners. Each pump station is equipped with three progressive cavity pumps operating through SCADA. Pumping must be carefully controlled due to limited capacities in the conveyance piping to the digesters.

Centrifuge Thickening

From the WAS wet well, non-clog centrifugal pumps deliver WAS to three thickening centrifuges, of which only two units are usually operated. The feed has a typical solids concentration of 0.5 to 0.6 percent solids. Thickening centrate from the centrifuges is recycled back to the headworks.

The WAS is thickened to approximately five percent solids and is discharged to a wet well from where two, four-stage progressive cavity pumps discharge to the anaerobic digesters. The distribution of the WAS to the digesters is programmed through SCADA to enable near equal amounts to be sequentially fed to each digester.

Anaerobic Digestion

The anaerobic digestion system consists of eight, 2.27 million gallon anaerobic digesters, equipped with mechanical mixers and recirculation sludge heating systems using heat exchangers. The digester biogas is used to fire the hot water boilers for heating the digesters, while the unused gas is flared. A combined heat and power (CHP) project is in the planning stages to utilize biogas for power and thermal supply.

Figure 4-4
Anaerobic Digester

Figure 4-5
Heat Exchanges in Digester Complex

Solids Dewatering and Disposal

The digested sludge is stored in one of two, 2 million gallon storage tanks from which it is pumped to the dewatering system. The plant operates one centrifuge at a time and typically produces an 18 to 19 percent solids dewatered cake. A screw press is currently on site for pilot testing. Dewatered cake is transferred from the centrifuges to four storage silos by shaftless screw conveyors prior to transfer by truck to the onsite RMF for storage.

Residuals management services are performed at the RMF, where Class B biosolids are stored prior to land application. The RMF is a pre-engineered, steel building facility originally intended for Class A lime stabilization and composting operations, but is currently used as a storage facility. The dewatered cake is hauled by dump trucks from the storage silos to the RMF where biosolids are allocated into one of five batches, which are typically filled one at a time. The storage is needed to stage land application events and to address the fecal coliform increase that occurs in the biosolids cake. During the storage time, fecal coliform populations increase and then decrease in numbers. Residence time of the cake in storage is dependent upon testing results showing sufficient fecal coliform reduction, which is historically seasonally dependent, and has ranged from nearly no storage requirement in the summer to over two months of storage time during winter operations.

Figure 4-6
Dewatering Centrifuge

4.1.1 McAlpine Creek WWMF Operational Constraints and Improvements

Gravity Thickened Sludge Pipelines

Gravity thickened sludge pumps deliver through 8-inch pipelines to a point where they connect to older 6-inch piping, the condition of which is questionable since it was installed as part of the original plant construction. Modeling of this piping system was developed in the past to identify limiting flow and pressure conditions for the 6-inch pipelines. The 6-in and 8-in piping to the digesters appears to have hydraulic issues creating capacity bottlenecks limiting operating pressure and flow rate. Grease accumulation in these lines is a growing concern and likely contributing to conveyance capacity issues.

Digesters

- The digester mixers in the four new digesters (Digester 5 through 8) are not operating properly. Electrical conditions suggest broken propellers and/or shafts. Removal and repair of these units is planned for the near future.

- Digester 7 was recently drained to check the condition of the mixers. The propeller blade on one of the mixers had sheared off. In order to properly repair this mixer, the manufacturer will be reviewing their design to correct any issues that lead to failure of this unit. It is suspected that the mixers in other digesters may have a similar problem. CMUD expressed interest in reviewing alternative mixing technologies for these mixers while current mechanical mixer issues are being addressed. In the meantime, a new spare gear drive had been purchased.

Gravity Thickeners

The mechanical switches used for scum flushing in the thickener scum box for the two new gravity thickeners do not function properly. Solenoid switches to control box flushing used in the older thickeners provide more reliable performance and are preferred by plant staff.

WAS Pumping Station/Wet Well

The WAS wet well is part of one of the older treatment units at the plant. It has been modified over the years to receive increasing amounts of WAS from McAlpine Creek WWMF and Sugar Creek WWTP.

According to plant staff, the 100,000 gal WAS wet well is not adequately sized to provide operational flexibility and reliability. The limitations of the current facility present a bottleneck for processing WAS from the McAlpine and Sugar Creek facilities, impacting thickening operations and performance which in turn impacts digester feed conditions and operations.

Screw Conveyors

The shaft-less screw conveyors capable of transferring the biosolids cake to the RMF storage facility. While the conveyor is exercised, its ability to reliably transport cake to the RMF is uncertain. Use of the conveyor to transport and properly distribute the cake in the RMF for storage would require significant modifications.

Biosolids Dewatering

- The two PM 95000 Alfa Laval dewatering centrifuges have sufficient capacity to handle the current sludge production. According to plant staff, these units were marketed to produce approximately 20-21 percent solids, while the 18-19 percent solids cake being generated (with one unit stand-by) creates storage challenges and higher land application and landfill costs. Given the large production of biosolids at McAlpine Creek WWMF, dewatering performance is a key element in reducing the cost of handling and final deposition of the biosolids product.
- Final dewatered cake continues to exhibit fecal coliform regrowth/die-off conditions for a period after dewatering which compounds the need for additional storage particularly during winter periods.

Polymer Feed System

Use of a common polymer feed system for both thickening and dewatering operations creates less than optimum polymer compatibility for optimum thickening and dewatering performance.

Biosolids Storage Area

The storage capacity of the RMF will not be sufficient to accommodate future increases in solids production at the current dewatering performance of the current dewatering approach.

4.2 Irwin Creek WWTP Process Description

Irwin Creek WWTP is one of Charlotte's oldest facilities, built in 1927 as a twin plant to the Sugar Creek WWTP. It is located at the end of Westmont Drive and discharges into Irwin Creek, a tributary of the Catawba River.

The plant is permitted for a treatment capacity of 15-mgd and the current average flow rate through the plant is approximately 7.8-mgd. A simplified process flow schematic is shown in **Figure 4-7**.

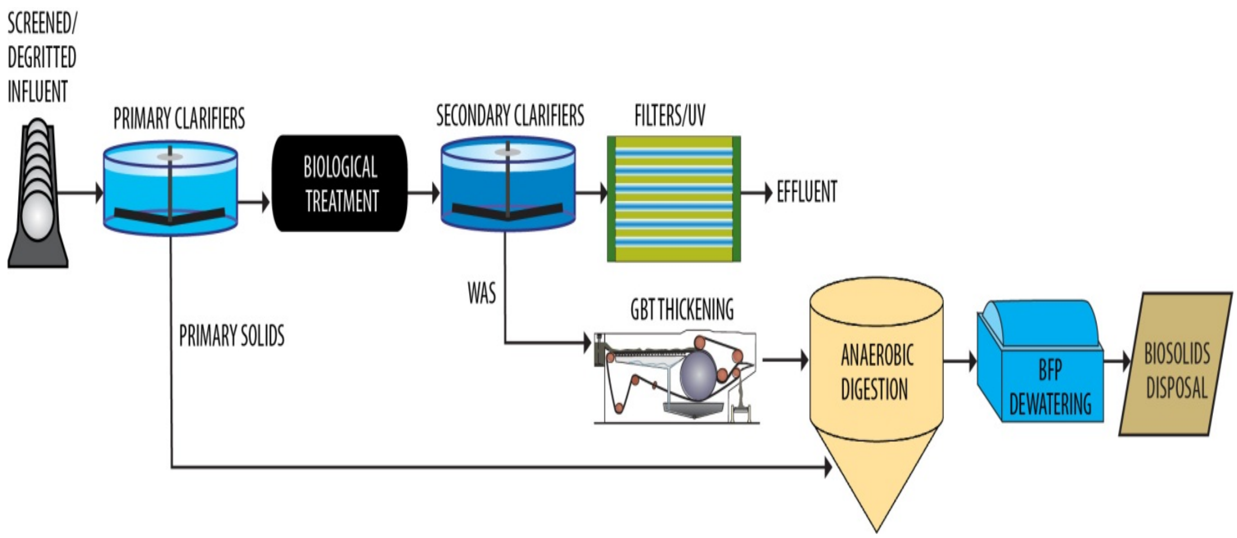

Figure 4-7
Irwin Creek WWTP Process Flow Schematic

Primary Sludge

The facility has three 125-foot diameter primary clarifiers, of which only two units (PC-1 and PC-2) are operated. Primary sludge is collected, combined with floating scum, and conveyed to a wet well outside the clarifier. The primary sludge is pumped using air diaphragm type pumps to the primary digesters.

Secondary Sludge

WAS from three 125-foot diameter secondary clarifiers can either be pumped directly to the primary anaerobic digesters, or to a 360,000 gal storage tank. The tank is mixed using course bubble diffused aeration. Air is supplied by two positive displacement blowers.

WAS Thickening

From the WAS storage tank, sludge is pumped to two 1.5-meter gravity belt thickeners (GBTs), of which only one unit is used at this time. The GBT produces approximately five percent solids. Two progressive cavity pumps transfer the thickened waste activated sludge (TWAS) to the primary digesters. These pumps experience pumping problems if thickened sludge approaches six percent solids.

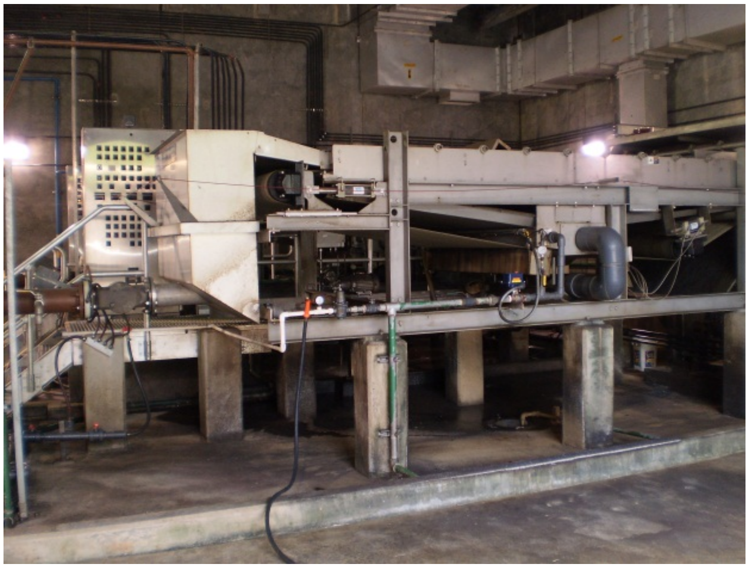

Figure 4-8
Gravity Belt Thickener

Anaerobic Digestion

The stabilization system consists of four 0.62 million gallon, 65-foot diameter covered primary anaerobic digester tanks, each with a dedicated mixer, a hot water and sludge recirculation system. In addition, two 0.62 million gallon, 65-foot diameter unheated, unmixed secondary digester tanks are provided with floating gas holder steel covers and biogas collection system.

Dewatering

Two progressive cavity pumps convey the solids from the secondary digester to a single, 2.2 million gallon Digested Sludge Storage Tank. From there, the stabilized sludge is fed to a BFP for dewatering. This unit was recently installed in the covered sludge storage area with a four year lease and maintenance contract.

Figure 4-9
Dewatering Belt Filter Press

Solids Storage and Disposal

The dewatered biosolids are stored on a covered storage pad, which also receives approximately four to five truckloads of residuals per day from Franklin WTP and four to five truckloads per week from McDowell Creek WRF (approximately 20 wet tons each). Access to this area and to the dewatering system is over an access bridge.

Figure 4-10
Covered Biosolids Storage Area

4.2.1 Irwin Creek WWTP Operational Constraints

Storage Area

The access bridge to the storage area appears to be in critical need of repairs. A new entrance is being considered by CMUD to avoid the trucks passing over the bridge.

Current Improvements

- Various improvements are currently under construction at the plant. Biosolids related improvements in Phase I include upgrades to the digesters, which have experienced operation and maintenance issues. Phase II will include upgrades to the primary clarifiers and dewatering equipment, as well as an upgrade to the polymer feed systems for thickening and dewatering. Sludge samples from the Irwin Creek WWTP will be tested as part of the ongoing piloting program with the Huber screw press at McAlpine Creek WWMF.

- A leased BFP is currently used for dewatering operations. It is expected that two new BFPs will be installed as part of Phase II improvements and the leased BFP removed. The current BFP is located in the biosolids storage pad area which is an open structure. One of the future improvements to be evaluated is relocation of the BFPs to either a new or rehabilitated building.

4.3 Sugar Creek WWTP Process Description

Sugar Creek WWTP was constructed in 1927 and is located in the South Park area of south Charlotte. It has a permitted treatment capacity of 20 mgd and a current flow of 13.2 mgd. A simplified process flow schematic is shown in **Figure 4-11**.

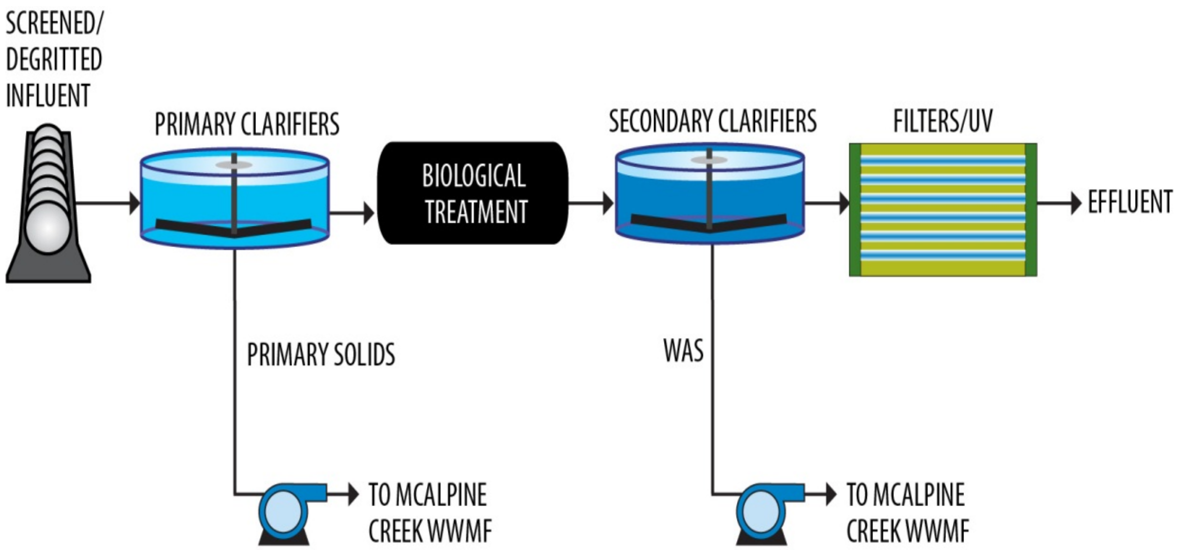

Figure 4-11
Sugar Creek WWTP Process Flow Schematic

Primary Sludge

Primary sludge is removed from four 110-foot diameter clarifiers and pumped to the McAlpine Creek WWMF for subsequent treatment. Each primary clarifier has a dedicated progressive cavity pump with grinders. A full spare is on-site as a back-up.

Figure 4-12
Primary Sludge Pump

Primary sludge travels approximately eight miles from Sugar Creek WWTP to McAlpine Creek WWMF through an 8-inch pipeline.

Secondary Sludge

Four 85-foot diameter and two 140-foot diameter secondary clarifiers are served by two separate RAS Pump Stations. Only the RAS Pump Station serving the larger clarifiers has sludge wasting capabilities. The pumps were recently equipped with VFDs and an updated SCADA control system is being programmed to increase flexibility in pumping operations.

Figure 4-13
Secondary Clarifier

WAS is pumped to the McAlpine Creek WWMF through an 8-inch pipeline. Only one pump is currently utilized. Maintaining scouring flow velocities in the line is a current operational condition that impacts the WAS transfer to McAlpine Creek WWMF. Intermittent pump operation is required to deliver WAS flows over short periods to McAlpine Creek WWMF due to the limitations of the McAlpine Creek WWMF WAS pumping station.

Two interconnects are present between the primary and the secondary sludge lines at the Sugar Creek WWTP and at the McAlpine Creek ends of the pipeline.

Digestion

There are four decommissioned digesters present on the site, each with 1.2 MG storage capacity. Currently one digester could be used for the storage of primary solids if the transfer of sludge to McAlpine Creek WWMF had to be interrupted for extended periods. Sludge pumped to this tank must be pumped back into the headworks at the Sugar Creek WWTP using temporary pumps and piping, as a permanent pipe path no longer exists.

Potential Facility Upgrades

A Sugar Creek WWTP expansion and upgrade project was developed but the construction of the completed design has been delayed indefinitely. According to the plan, sludge handling was to continue with the present transfer program.

4.3.1 Sugar Creek WWTP Operational Constraints

Sludge Transfer Lines to McAlpine Creek WWMF

- Primary sludge and WAS transfer lines to McAlpine Creek WWMF have never been inspected or cleaned, as they are not provided with pigging capabilities. Cleaning operations are impractical since there are no intermediate stations for access of cleaning equipment between the two facilities. An upgrade to these pipelines may therefore be considered due to their age, lack of cleaning access, and lack of booster pump stations.

- Minimum scouring velocities of 2-feet per second (corresponding to 325 gpm) is maintained in the 8-inch WAS transfer line to McAlpine Creek WWMF. Therefore, as WAS sludge concentrations or production rates change over time, the pumps need to be operated intermittently to discharge the targeted WAS , creating shorter and more intense wasting periods which impacts WAS handling and thickening operations at McAlpine.

- The existing primary sludge pumps have insufficient capacity to maintain minimum velocity requirements. Plant staff is currently evaluating the possibility of a flushing system to remove/control deposition in the pipelines.

- The pressure release/air relief valves along the pipeline have failed over the years and have been removed.

- Wasting from the older secondary clarifiers is not possible.

4.4 Mallard Creek WRF Process Description

The Mallard Creek Water Reclamation Facility (WRF) was built in 1979 to meet increased demand as the area northeast of Charlotte grew, and was renovated over the years to allow for greater treatment capacity. In 1998 Mallard Creek began operation of a new reclaimed water program, which uses treated wastewater for irrigation at The Tradition Golf Links and at Mallard Creek Park. The WRF was originally set up for BNR, but anticipated permit limits for nutrients were not imposed. Mallard Creek WRF is rated for 12-mgd, with a current average wastewater flow of 8-mgd. A simplified process flow schematic is shown in **Figure 4-14**.

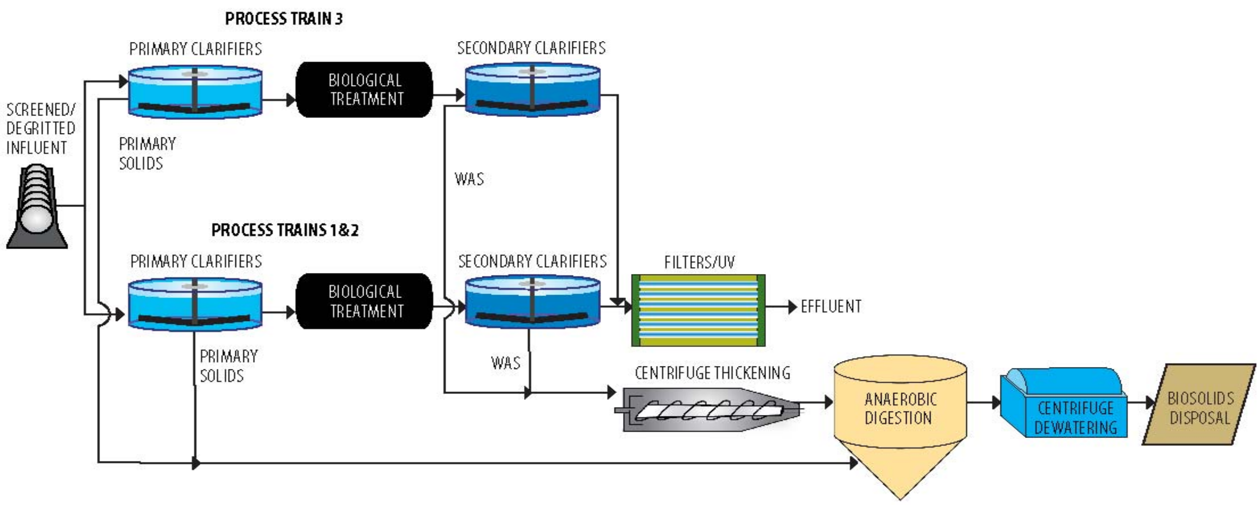

Figure 4-14
Mallard Creek WRF Process Flow Schematic

Primary Sludge

The plant consists of three process trains. Process Train 3 (PT 3) was implemented in the late nineties as part of the 12-mgd expansion, and treats wastewater separately from the original Process Trains 1 and 2 (PT 1&2). Wastewater influent from the headworks, which includes grit removal, is pumped to two 60-foot diameter primary clarifiers for PT 1&2 and one 85 foot diameter primary clarifier for PT 3.

From the primary clarifiers, the flow splits between the process trains. Currently, approximately 40 percent of the wastewater flow is conveyed to the biological treatment for PT 3, while 55 and 45 percent of the remaining wastewater are processed by PT1 and PT 2, respectively. Primary sludge is discharged to the primary digesters from air-operated diaphragm pumps located in two separate pump stations dedicated to PT 1&2 and PT 3.

Secondary Sludge

WAS from the two PT 1&2 final clarifiers merges with the WAS from PT 3 final clarifier and is pumped using progressive cavity pumps to the Dewatering Building, where it can be thickened or dewatered. Alternatively, it can also be pumped directly to the primary digesters. Thickened WAS is pumped to the four primary digesters using diaphragm pumps, which can discharge up to four percent solids.

Figure 4-15
WAS Pumping System

Thickening

Four centrifuges are located in the Thickening and Dewatering Building, of which the following units are currently used for thickening operations:

Centrifuge No. 3 is similar in size to Centrifuge No. 1 and is used for WAS thickening only. Centrifuge No. 4 has similar capacity to Centrifuge No. 2 and can thicken or dewater. However, since the conveyor does not extend to this unit, it is only used for WAS thickening.

Anaerobic Digestion

The WRF is equipped with four primary anaerobic digesters. The three original primary digesters (Digesters 2, 3 and 4) have a capacity of 0.52 million gallons each, while the newer tank (Digester 5) has a capacity of 1.32 million gallons. Each unit is equipped with four draft tube mixers and is heated using biogas boilers and spiral heat exchangers. Stabilized sludge can be withdrawn using progressing cavity pumps at three transfer water levels. One unheated, unmixed secondary digester tank (Digester 1) with a capacity of 0.52 million gallons is used for holding digested sludge prior to dewatering. Biogas that is not used for digester heating is flared which occurs most of the time.

Figure 4-16
Anaerobic Digestion

Dewatering

Two centrifuges located in Thickening and Dewatering buildings are used for dewatering.

- Centrifuge No. 1 has limited capacity and has dewatering and thickening capabilities. It is used for dewatering only when Centrifuge 2 is not available to operate.
- Centrifuge No. 2 is a larger unit, and is normally used for all dewatering operations.

Figure 4-17
Thickening and Dewatering Centrifuges

Solids Storage and Disposal

Dewatered cake is discharged directly onto hauling trucks operated by Synagro for direct hauling off site or transported by plant staff to a covered area where it is stored in separate piles organized by month of production. The biosolids cake has experienced fecal coliform regrowth issues similar but not as severe as the cake at McAlpine Creek WWMF. The separate piles allow for sampling and monitoring confirming fecal coliform compliance. On-site storage capacity is up to four months of sludge production at current production rates.

Figure 4-18
Solids Hauling and Storage

4.4.1 Mallard Creek WRF Operational Constraints

Plant Improvements Underway

The plant is currently undergoing improvements to unify the primary and secondary treatment systems into a "one-sludge" operation (common clarification and RAS). Other improvements will involve demolition of old structures to make way for the improvements. No impacts to the current sludge conditions or production are anticipated due to these improvements.

Anaerobic Digestion

- Primary sludge and thickened sludge diaphragm pumps limit operations and performance due to the relatively thin solids concentrations needed for sludge delivery to pump suction. Thickened WAS over 3.5% creates pumping problems and addition of dilution water is required.

- Biogas analyzers are not available for the digesters, and the biogas flow meter measuring gas from digesters to boilers does not operate properly.

- This facility is the only WWTP operated by CMUD that lacks a biogas scrubbing system, which has led to corrosion issues in the gas handling system. Digester gas scrubbing improvements are included in the current maintenance schedule.

- Plant has experienced difficulties in maintaining proper sludge temperature in Digesters 3 and Digester 4 during winter conditions.

- Frequently, rags get trapped in the draft tube mixers. This issue is not as critical as it used to be since the influent screens have been replaced.
- Stratification in the secondary digester (Digester 1) occurs at times impacting dewatering performance. Recirculation pumping is used to remix the tank. With a focus on more consistent thickened WAS sludge concentration near 3.5%, separation in this tank as become less of an issue.

Thickened and Primary Sludge Pumping

- Thickened WAS sludge and primary sludge are pumped to the digesters using diaphragm pumps which require significant maintenance for operation and are prone to clogging.
- The capacities and configuration of the centrifuges create obstacles for optimizing thickening and dewatering performance.
- Use of a common polymer feed system for both thickening and dewatering operations creates less than optimum polymer compatibility for optimum thickening and dewatering performance.

Dewatered Cake Truck Loading Area

- Loading operations and housekeeping procedures to prevent spillage from trucks or tracking of mud and debris are maintenance intensive.

4.5 McDowell WRF Process Description

McDowell Creek WRF was established in 1980 in Huntersville. Since then it has been upgraded twice to expand its treatment capacity as demand increased in the areas north of Charlotte. Because McDowell Creek WRF discharges into McDowell Creek, a waterway that has been identified as nutrient-sensitive, the plant uses biological nutrient removal as part of its treatment process. This advanced treatment process includes removal of nitrogen and phosphorous. McDowell Creek WRF is rated for 12 mgd. The current wastewater inflows average 4.7 mgd. A simplified process flow schematic is shown in **Figure 4-19**.

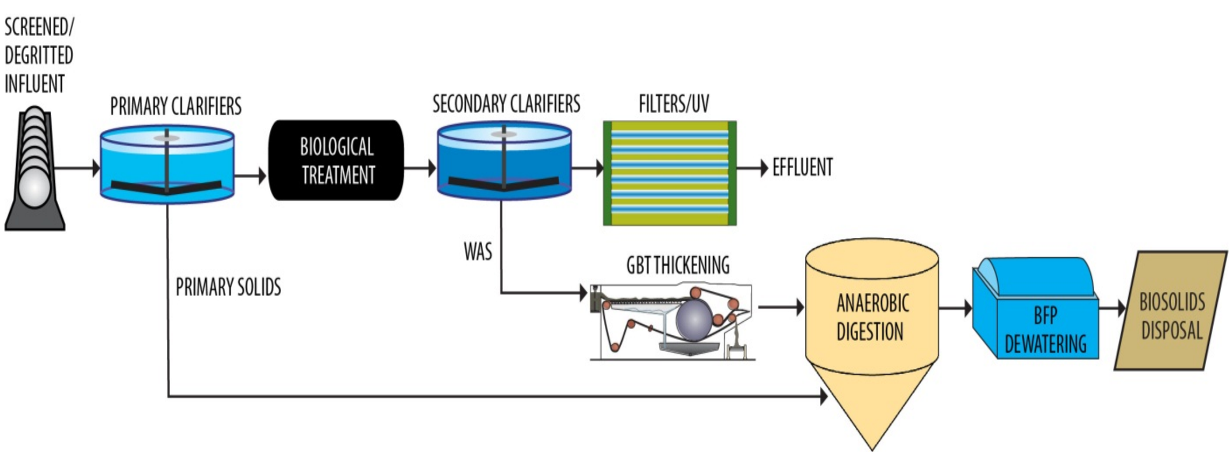

Figure 4-19
McDowell Creek WRF Process Flow Schematic

Primary Sludge

Primary sludge is pumped from two 55-foot and three 70-foot diameter primary clarifiers to the anaerobic digesters using diaphragm pumps. These pumps are located in the Primary Sludge Pump Station and operate on a timed basis. Ferric chloride can be added to the primary influent. The primary sludge pumps perform satisfactorily and have the advantage of being capable to run dry. The frequency of flow can be adjusted based on the sludge blanket in the clarifiers.

Secondary Sludge

WAS from four 100-foot final clarifiers (of which two are out of service) is pumped using progressive cavity pumps to a 250,000 gal WAS holding tank, equipped with coarse bubble diffusers.

Thickening

From the WAS holding tank, WAS is discharged with two progressive cavity pumps and two centrifugal pumps to the thickening process. The thickened WAS is combined with the primary sludge flow into the digesters. Thickening is achieved using two 1.5 meter GBTs which are operated one at a time, on a continuous basis. Polymer is fed ahead of the GBT to improve thickening performance.

Anaerobic Digestion

A total of five anaerobic digesters are located at the McDowell Creek WRF. Three original 0.48 million gallon primary digesters (Digesters 1, 2 and 5) are equipped with floating covers, while the newer 1.43 million gallon Digester 5 has a fixed dome. All primary digesters have draft tube mixers and spiral heat exchangers. The biogas is used in the boilers, while the unused gas is flared. No stratification is experienced, as the sludge is properly mixed by draft tube mixers inside the tanks. The pumping equipment and the heat exchangers perform properly. The stabilized sludge is discharged by gravity from the primary digesters to one secondary unheated and unmixed digester for gas storage. This unit (Digester 3) has a floating cover and a capacity of 0.48 million gallons. The biogas scrubbers on-site are effective at removing hydrogen sulfide and require minimum maintenance. Media replacement is dependent upon hydrogen sulfide removal performance.

Figure 4-20
Anaerobic Digester with Fixed Cover

Dewatering

Progressive cavity pumps transfer the stabilized solids from the secondary digester to two, 2-meter BFPs operating on a four days per week, eight hours per day schedule. Only one BFP at a time is needed for dewatering the current sludge production.

Biosolids Storage and Disposal

The dewatered cake is conveyed by a belt conveyor to a storage area where it can be both loaded onto hauling trucks and transported to Irwin Creek WWTP prior to land application, or discharged to a covered pad for storage on site. A blade installed on the belt conveyor allows operators to direct the cake to either one of these two options. The storage area has one month of storage at current flows.

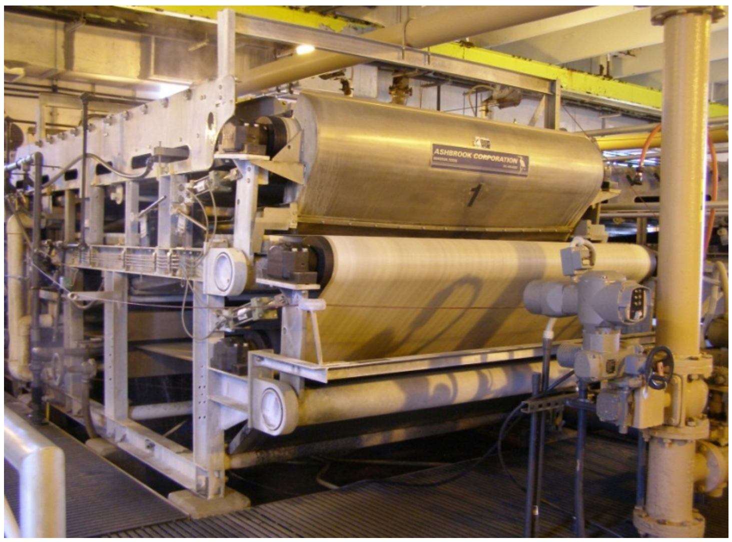

Figure 4-21
Dewatering Belt Filter Press

4.5.1 McDowell Creek WRF Operational Constraints

Dewatering Building

Corrosion is evident in the dewatering building. It has been speculated that this is due to inadequate ventilation.

Digestion and Dewatering:

- Struvite accumulation has been observed in the recirculation pipes/pumps in the Digester Building, on the BFP rollers and drain pans, and in the BFP filtrate pipes and pumps. The struvite in the filtrate system has been controlled using alum and a ferric chloride feed system for dosing ahead of the BFP is being implemented. An evaluation is underway to evaluate improved measures for struvite control.

- Dewatering performance has historically been poor with cake solids achieving 12-13 percent. Ferric chloride addition seems to have improved performance slightly but performance is still well below normal standards which commonly achieve a minimum 18 percent cake solids.

- The older digesters, in particular with regards to the covers, appear to be significantly degraded due to aging and corrosion. A detailed assessment of these structures should be conducted. The condition of the covers is addressed in the current maintenance schedule.

Section 5

Wastewater Treatment Plant Biosolids Production

This section presents historic and projected wastewater flows and solids production for the five WWTPs owned and operated by CMUD up to year 2035.

5.1 Background

A Wastewater Treatment Plant Expansion Study (CH2M Hill, May, 2007), was developed to determine treatment capacity needs for the McAlpine Creek WWMF, Irwin Creek WWTP and Sugar Creek WWTP. This report forecasted flow projections based on 2005 Traffic Analysis Zone (TAZ) data to project population increase within each WWTP's drainage basins over the next 20 years.

In 2012, a review of historical wastewater flow data suggested that the 2007 study included fairly aggressive projections for the Irwin Creek WWTP, and lead to updated forecasts for this plant, as presented in the Irwin Creek Wastewater Treatment Plant Preliminary Engineering Report (Hazen & Sawyer, 2012). The conclusions in the 2007 and 2012 studies were used as a basis for the preliminary analysis of wastewater flow projections in CMUD's service area, which are affected by several factors including: future construction of the proposed Long Creek WWTP, expanded treatment capacity of the Sugar Creek WWTP, treatment of wastewater flows from Union County, and the ability of the system to divert wastewater flows from Irwin and Sugar Creek WWTPs to McAlpine Creek WWMF.

CDM Smith presented preliminary forecasts for wastewater flows and solids production at Workshop No. 1 conducted on September 5, 2012. These projections were based on the available studies referenced above and plant historic daily operation summaries between year 1998 and year 2012. The results of this preliminary analysis were further updated to address revised growth projections as forecasted by CMUD and as summarized in this section.

5.2 Historic and Projected Wastewater Flows

5.2.1 Mallard Creek WRF

No wastewater flow projections are available for the Mallard Creek WRF which is rated for a permitted monthly average flow of 12-mgd.

As recommended by CMUD during Workshop 1, Mallard Creek WRF annual average wastewater flow projections were enveloped between a 'moderate' growth and an 'aggressive' growth curve up to year 2035, as shown in **Figure 5-1** and summarized in **Table 5-1**.

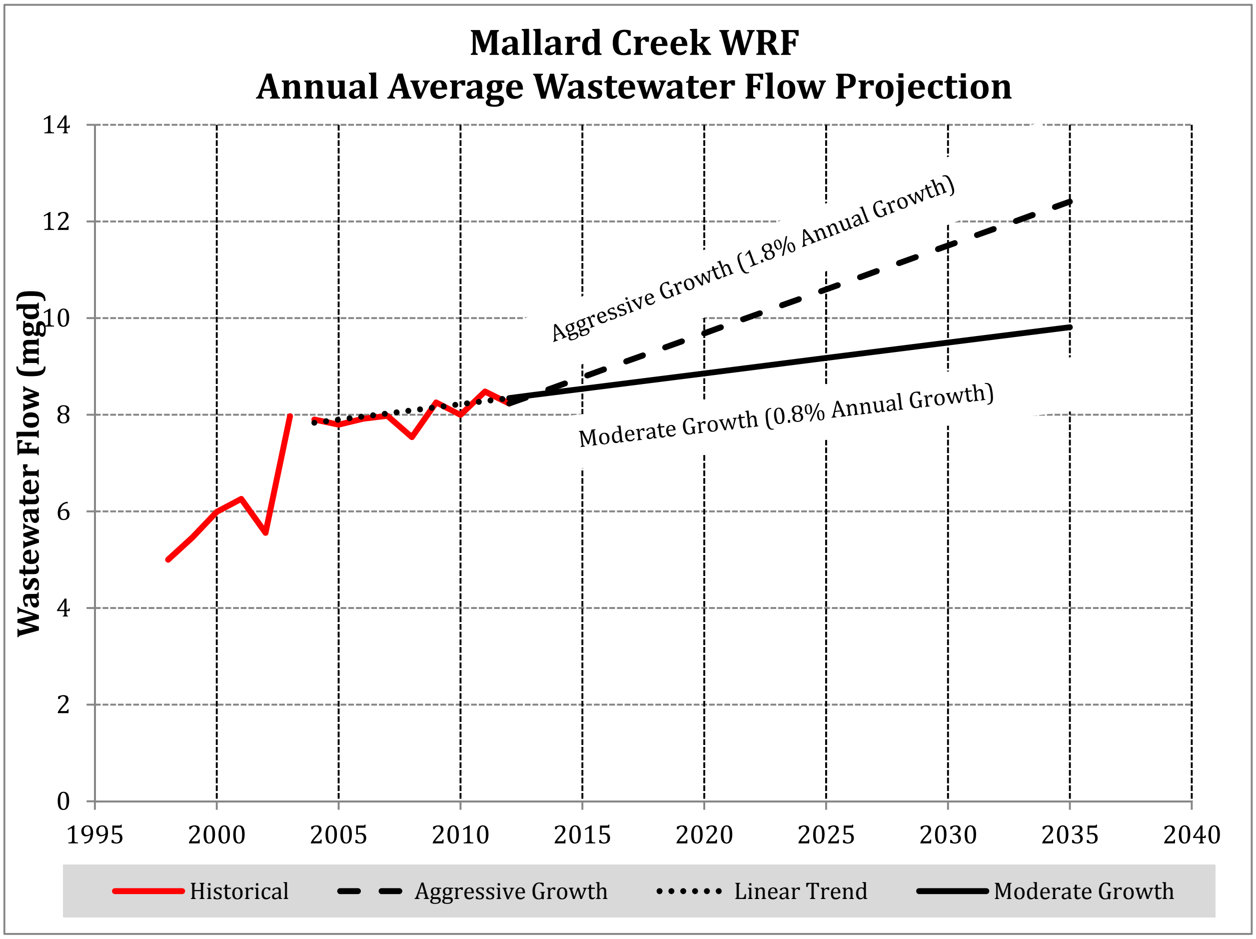

Figure 5-1
Mallard Creek WRF – Annual Average Wastewater Flow Projection

Table 5-1 Mallard Creek WRF – Annual Average Wastewater Flow Projection

Year	Wastewater Flow Projection (mgd)	
	Moderate	Aggressive
2015	8.5	8.7
2020	8.9	9.5
2025	9.2	10.4
2030	9.5	11.4
2035	9.8	12.4

- The 'moderate' growth projection consists of a linear trend of the historical data from year 2004 to year 2011. This trend therefore does not account for the effect of significant storm events that occurred in year 2003 that would have skewed the projections. The linear trend line was shifted forward in time to intersect the observed data measured in year 2011 and represents a 0.8 percent rate of annual increase.

- The 'aggressive' growth projection assumes a 1.0 percent increase with respect to the 'moderate' trend, representing approximately a 1.8 percent rate of annual increase, but shifted forward in time to intersect historical flows. This projection shows a similar growth pattern to the linear trend of all the historical data between year 1998 and year 2011.

5.2.2 McDowell Creek WRF

No wastewater flow projections are available for the McDowell Creek WRF which is rated for a permitted monthly average flow of 12-mgd.

As recommended by CMUD during Workshop 1, the projected wastewater flows for McDowell Creek WRF will experience a 1.0 percent rate of increase up to year 2035 as shown below in **Figure 5-2** and are summarized in **Table 5-2.**

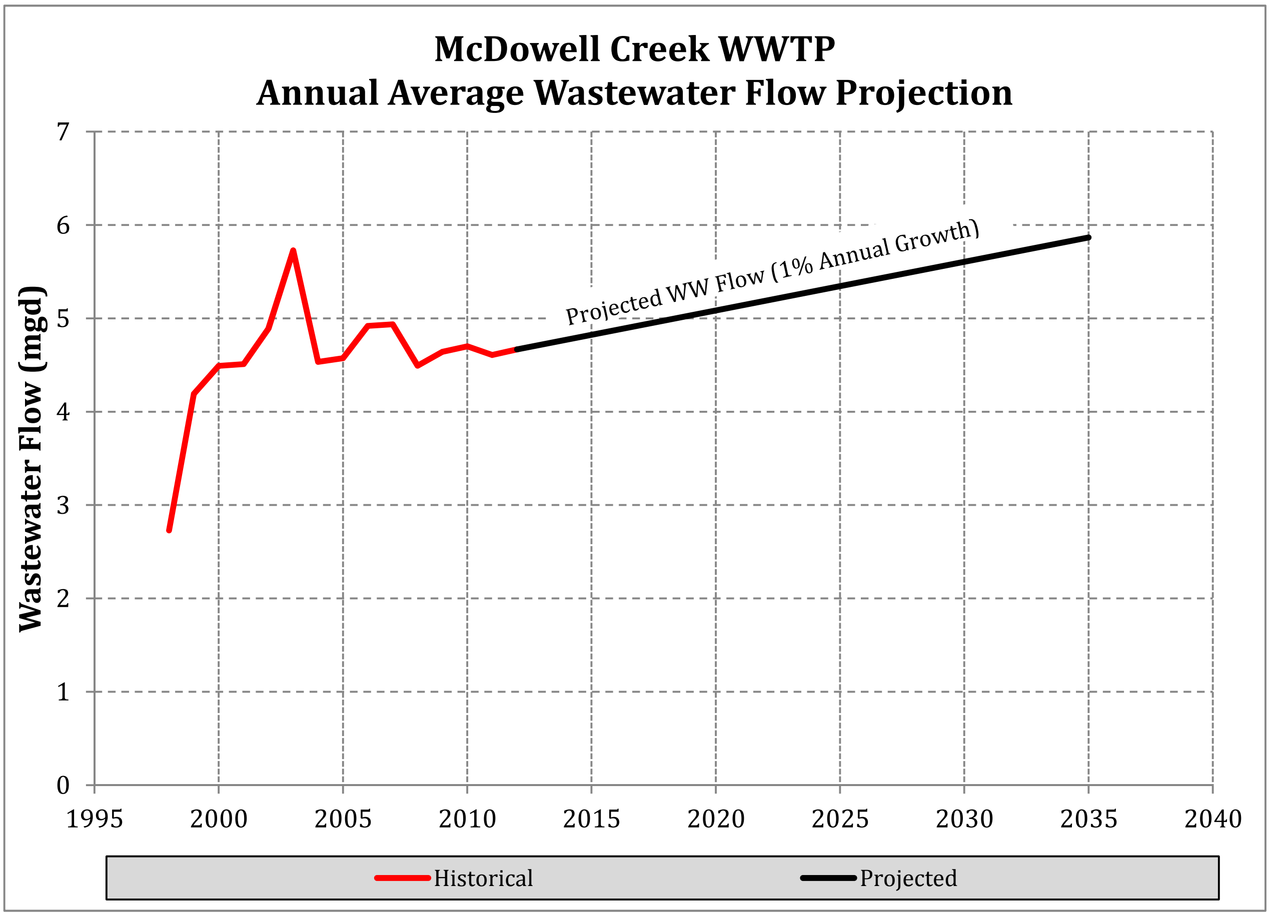

Figure 5-2
McDowell Creek WRF – Annual Average Wastewater Flow Projection

Table 5-2 McDowell Creek WRF – Annual Average Wastewater Flow Projection

Year	Wastewater Flow Projection (mgd)
2015	4.8
2020	5.1
2025	5.3
2030	5.6
2035	5.9

5.2.3 Sugar Creek WWTP

Sugar Creek WWTP is rated for a monthly average flow of 20-mgd but due to hydraulic limitations cannot process more than 18-mgd. Due to phosphorus discharge limits that apply to the combined flows from McAlpine Creek WWMF, Sugar Creek WWTP, and Irwin Creek WWTP, Sugar Creek WWTP has been limited by CMUD to treat flow up to 13-mgd. Flow exceeding 13-mgd is diverted to McAlpine Creek WWMF where enhanced phosphorus removal is provided.

Since the Sugar Creek basin is nearly built out, it offers limited potential for future growth. Therefore, as indicated by CMUD, annual average wastewater flow projections for Sugar Creek WWTP will be based on the following criteria:

- The combined wastewater flow treated at Sugar Creek WWTP and bypassed to McAlpine Creek WWMF will have a 0.5 percent annual rate of flow increase.
- Sugar Creek WWTP will continue to treat up to 13-mgd until chemical phosphorus removal is implemented by year 2022. From then on, the processing capacity at the plant will be increased to 16-mgd up to year 2035.
- Excess flows for the entire duration of the planning period will continue to be bypassed to McAlpine Creek WWMF.

A summary of the forecast for Sugar Creek WWTP is shown in **Figure 5-3** and is summarized in **Table 5-3**.

Table 5-3 Sugar Creek WWTP – Annual Average Wastewater Flow Projection

Year	Wastewater Flow Projection (mgd)
2015	13.0
2020	13.0
2025	16.0
2030	16.0
2035	16.0

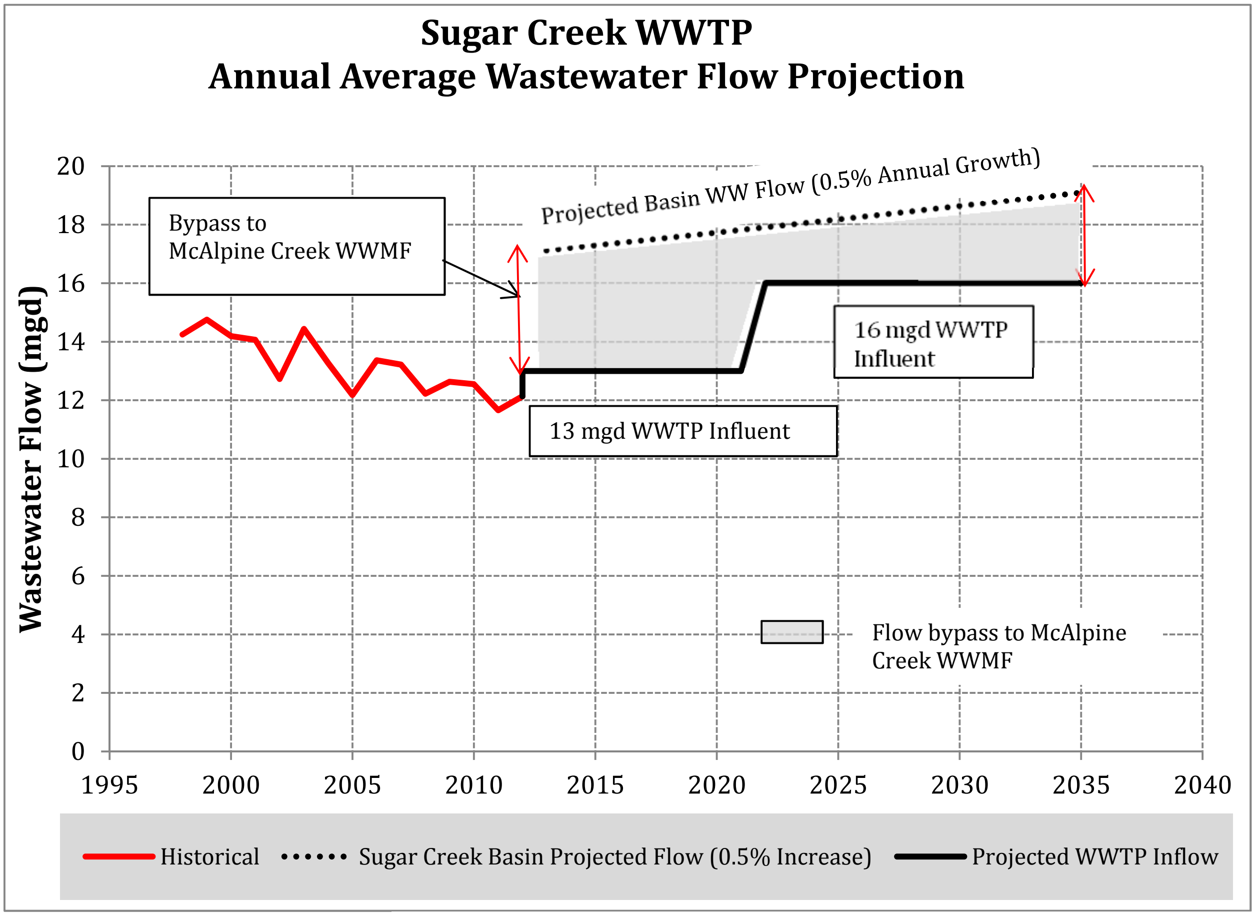

Figure 5-3
Sugar Creek WWTP – Annual Average Wastewater Flow Projection

5.2.4 Irwin Creek WWTP

The Irwin Creek WWTP has a rated monthly average capacity of 15-mgd. Original wastewater flow projections developed by CMUD for Irwin Creek WWTP assumed a 2.0 percent annual rate of increase in flows processed at this facility. During Workshop 1, CMUD commented that this rate of growth may be too aggressive and requested that a 1.0 percent annual rate of increase be used, as shown in **Figure 5-4** and summarized in **Table 5-4**.

Other criteria used to forecast wastewater flows at Irwin Creek WWTP are as follows:

- Irwin Creek WWTP maximum treatment capacity will remain 13.5 mgd throughout the planning period.
- Estimated 1.3-mgd will be conveyed from Taggart Creek sewer to Irwin Creek WWTP after completion of the sewer expansion in year 2013.
- Starting in year 2016, wastewater streams from Taggart Creek, Long Creek pump station, Town of Belmont, and Paw Creek pump station will be discharged to Irwin Creek WWTP. Ongoing upgrades at the plant are expected to be completed by then.

- Flow in excess of Irwin Creek WWTP's capacity (approximately 2.5 mgd from year 2016) will be bypassed to McAlpine Creek WWMF.
- Construction of Long Creek WWTP will be completed in year 2020. Flows from Long Creek pump station will stop being treated at Irwin Creek WWTP and will be discharged at the new facility in conjunction with flows from the city of Mount Holly.
- It is estimated that the Irwin Creek WWTP will reach its capacity in 2034. Excess flows will be bypassed to McAlpine Creek WWMF. It is assumed that Paw Creek pump station will continue to discharge to Irwin Creek WWTP.

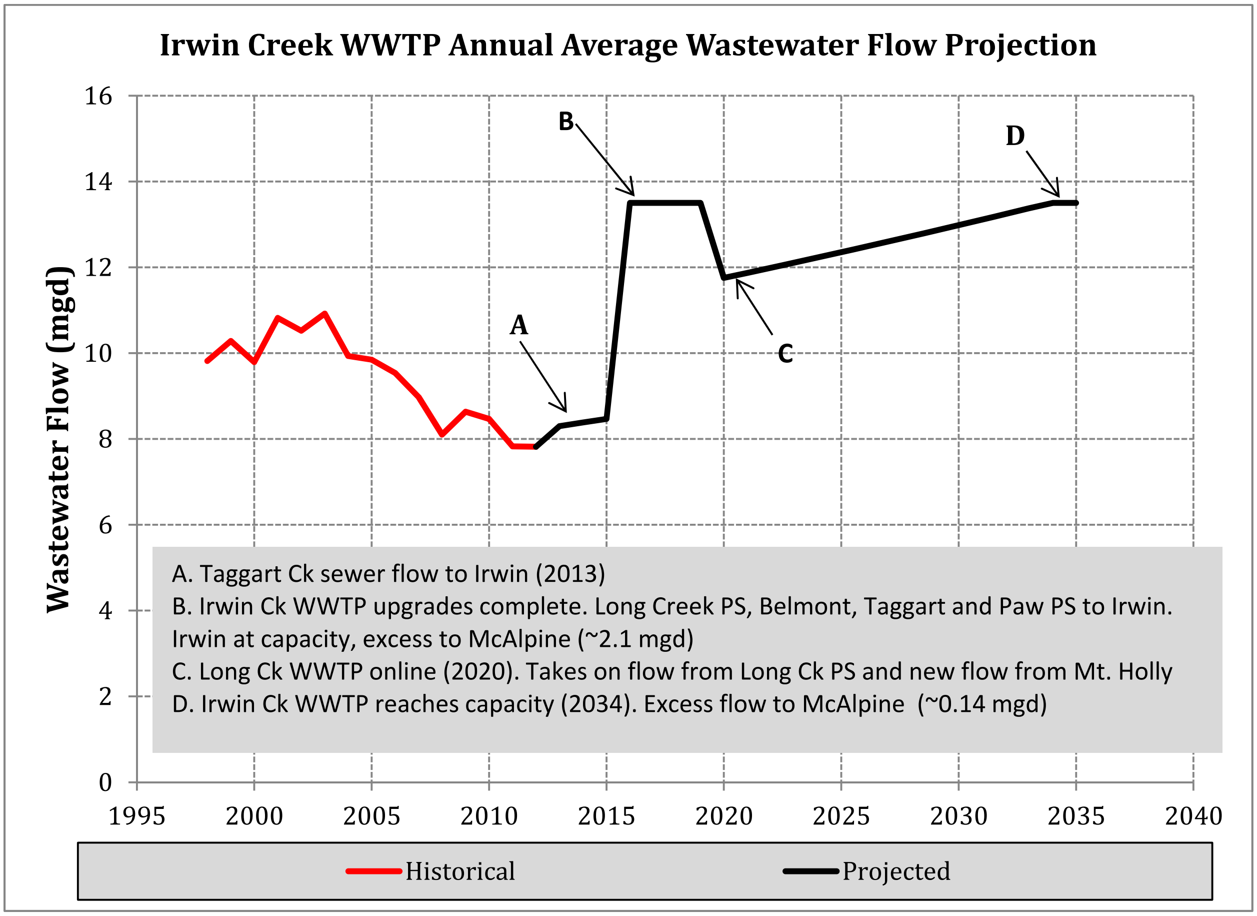

Figure 5-4
Irwin Creek WWTP – Annual Average Wastewater Flow Projection

Table 5-4 Irwin Creek WWTP – Annual Average Wastewater Flow Projection

Year	Wastewater Flow Projection (mgd)
2015	8.5
2020	11.8
2025	12.4
2030	13.0
2035	13.5

5.2.5 McAlpine Creek WWMF

McAlpine Creek WWMF is rated for a monthly average flow of 64-mgd and treats intermittent flows from the Irwin Creek basin, as well as flows bypassing Sugar Creek WWTP.

A preliminary wastewater flow projection was based on the 2007 Study forecast which was shifted forward in time to intersect historical flows while maintaining the same growth pattern of the 2007 predictions. This corresponded to a 2.0 percent annual rate of increase reaching 67.8-mgd of annual average flow in year 2035.

During Workshop 1, the McAlpine WWMF projections were further modified based on the following considerations as requested by CMUD and as shown in **Table 5-5** and **Figure 5-5**.

- The wastewater flow projection for streams generated within the McAlpine basin will experience an annual rate of increase in flows of 1.5 percent. Although the growth in the region is expected to remain fairly steady and below this level, a conservative approach will be applied due to the criticality of McAlpine Creek WWMF.
- A constant flow of 2-mgd from Union County will be processed at McAlpine WWMF starting in 2013.
- Construction of Long Creek WWTP will be completed in year 2020.
- Upgrades to the Irwin Creek WWTP will be completed by 2016.

Table 5-5 McAlpine Creek WWMF – Annual Average Wastewater Flow Projection

Year	Wastewater Flow Projection (mgd)
2015	48.8
2020	46.4
2025	50.0
2030	53.9
2035	58.3

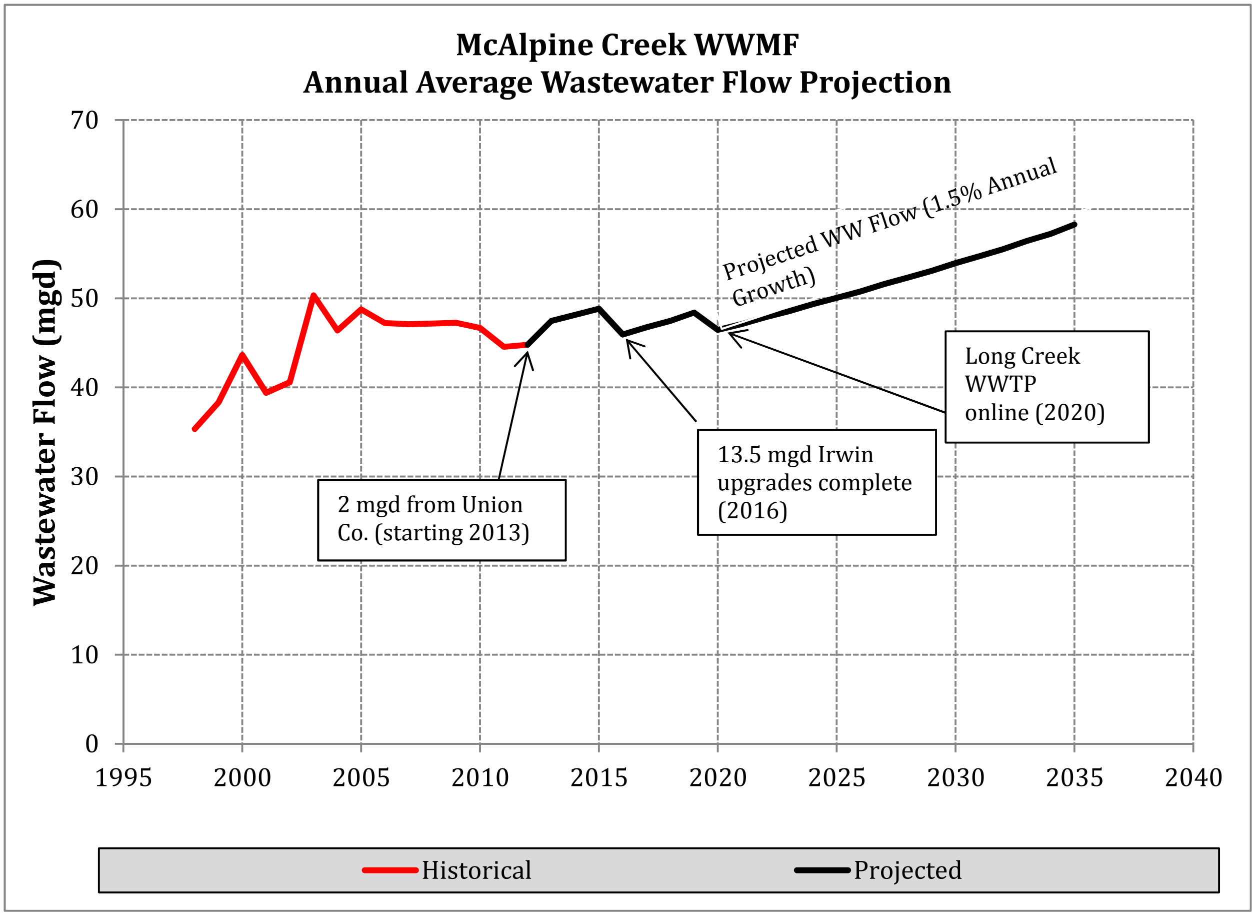

Figure 5-5
McAlpine Creek WWMF – Annual Average Wastewater Flow Projection

5.2.6 Long Creek WWTP

The Long Creek WWTP is projected to be rated for a monthly average capacity of 15-mgd. Wastewater flow projections developed by CMUD for this facility are shown in **Figure 5-6** and summarized in **Table 5-6.** The Long Creek WWTP is expected to come online in year 2020. It will treat 4.5-mgd from Long Creek pump station, previously discharged to Irwin Creek WWTP, and 3-mgd from the City of Mount Holly.

As requested by CMUD, the wastewater flow projections for Long Creek WWTP will be based on a 1.0 percent annual rate of flow increase up to year 2035.

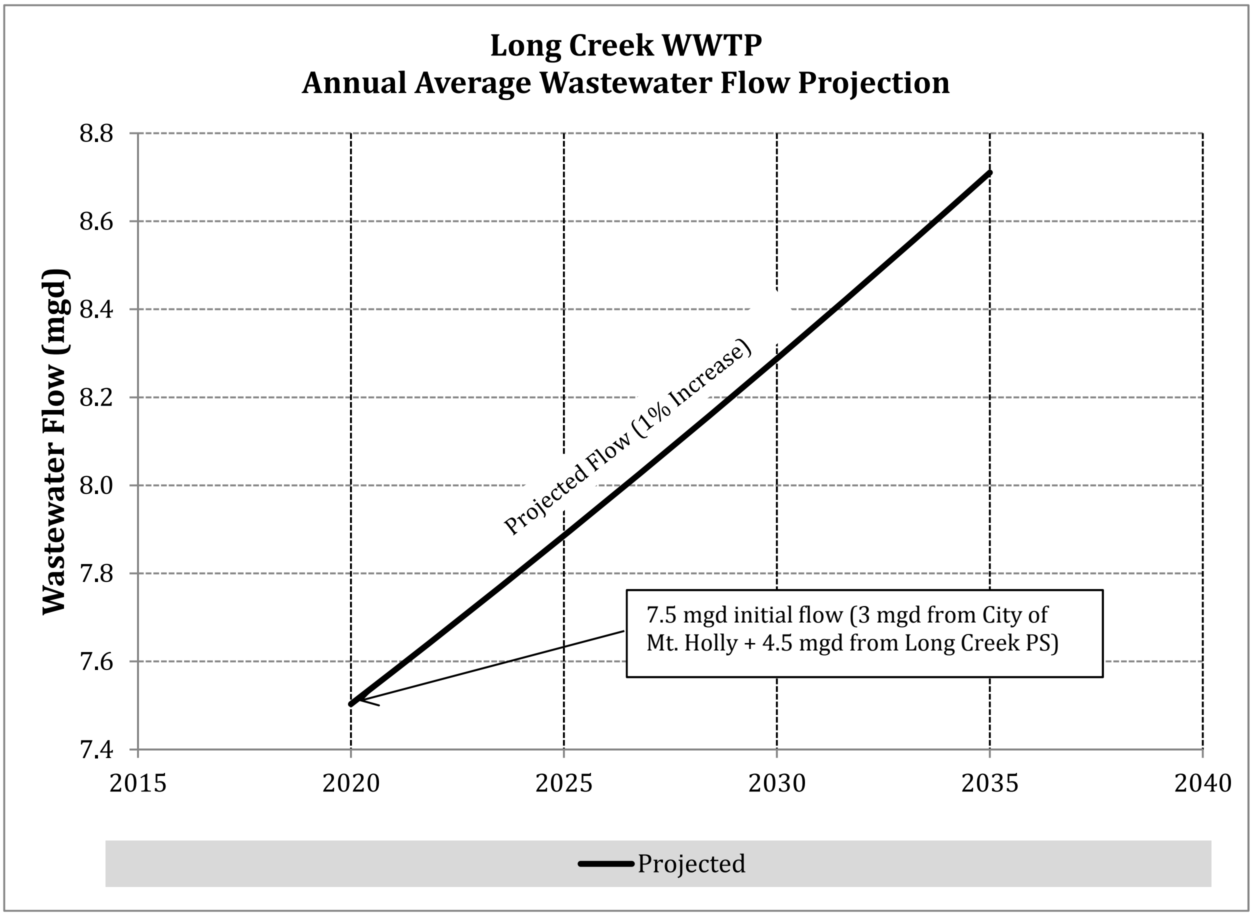

Figure 5-6
Long Creek WWTP – Annual Average Wastewater Flow Projection

Table 5-6 Long Creek WWTP – Annual Average Wastewater Flow Projection

Year	Wastewater Flow Projection (mgd)
2020	7.5
2025	7.9
2030	8.3
2035	8.7

5.3 Solids Production

For each facility the following approach was used to assess current and future solids production.

- Daily plant influent wastewater flows and quality data from January 2009 through December 2011 were analyzed to evaluate mass loadings and peaking factors. The average day maximum month (ADMM) loading rate was calculated as the 95th percentile of the 30-day moving average load. This parameter is typically used to size various processes (e.g., thickening and dewatering). Its peaking factor was generated by taking the ADMM load and dividing it by the average daily load for the study period.

- Based on the historic data, a mass balance for each WWTP solids process was developed, identifying the solids throughput for each process unit. Annual operations summaries prepared by Synagro for solids land applied and landfilled were compared against the results of the mass balance. The mass balance was then calibrated to model the biosolids disposed of (as reported by Synagro).
- Primary clarifier solids and waste activated solids (WAS) quantities were estimated based on available historic data, when available, and checked against the results of the mass balance analysis. Unit mass of solids in dry tons per million gallon (Mgal) and associated peaking factors were also determined.
- Future solids production was calculated by multiplying primary clarifier solids and WAS estimates at each plant (in dry tons per Mgal of wastewater treated) by the future wastewater flows up to year 2035.

5.4 Historical Influent Flows and Loads Characteristics

Historical wastewater characteristics were analyzed in conjunction with operating data at each facility. Plant effluent flows were typically used for this analysis since measurements of influent flows at the facilities include recycled sidestreams. Mass loadings and peaking factors for flow, 5-day carbonaceous biochemical oxygen demand (CBOD5) and total suspended solids (TSS) are summarized in **Table 5-7**.

5.4.1 McAlpine Creek WWMF

As illustrated in **Figure 5-7**, wastewater flows at McAlpine Creek WWMF have decreased by approximately 3-mgd in three years. However, solids loading rates have remained substantially constant due to increased CBOD and TSS concentrations.

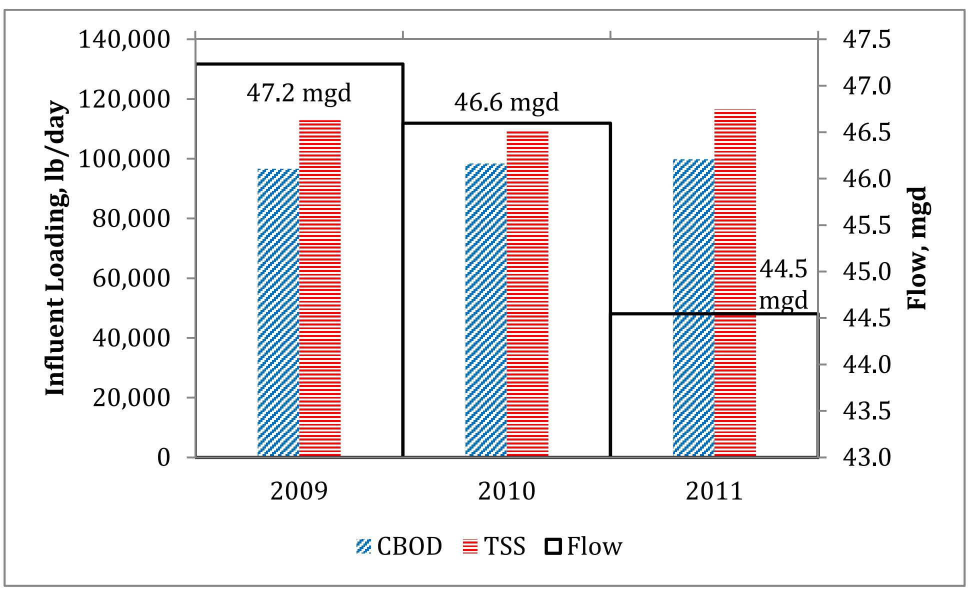

Figure 5-7
McAlpine Creek WWTP – Annual Influent Flow and Loadings

Table 5-7 Influent Mass Loading and Peaking Factors (2009-2011)

Parameter	Annual Average Day	Average Day Max Month	Peak Factor
McAlpine Creek WWMF			
Flow (mgd)	46.1	54.4	1.18
CBOD5 (mg/L)	257	293	1.14
CBOD5 (lb/d)	98,326	109,411	1.11
TSS (mg/L)	294	355	1.20
TSS (lb/d)	112,898	134,912	1.19
Sugar Creek WWTP			
Flow (mgd)	13.3	13.6	1.10
CBOD5 (mg/L)	263	299	1.14
CBOD5 (lb/d)	26,871	30,276	1.13
TSS (mg/L)	248	282	1.13
TSS (lb/d)	25,450	29,372	1.15
Irwin Creek WWTP			
Flow (mgd)	8.3	10.0	1.20
CBOD5 (mg/L)	304	346	1.14
CBOD5 (lb/d)	21,066	22,899	1.09
TSS (mg/L)	316	378	1.20
TSS (lb/d)	22,027	25,634	1.16
Mallard Creek WRF			
Flow (mgd)	8.2	9.2	1.13
CBOD5 (mg/L)	264	298	1.13
CBOD5 (lb/d)	17,927	19,726	1.10
TSS (mg/L)	256	300	1.17
TSS (lb/d)	17,408	20,372	1.17
McDowell Creek WRF			
Flow (mgd)	4.6	5.2	1.11
CBOD5 (mg/L)	277	313	1.13
CBOD5 (lb/d)	10,594	11,825	1.12
TSS (mg/L)	291	356	1.22
TSS (lb/d)	11,047	13,209	1.20

5.4.2 Sugar Creek WWTP

Flows processed at Sugar Creek WWTP have remained steady, while the percentage of flow bypassed to McAlpine Creek WWMF has decreased from nearly 7-mgd to 5-mgd. **Figure 5-8** shows that an increase in CBOD and TSS concentration has contributed to maintain solids loading rates fairly constant (approximately 27,000 and 25,000 dry pounds per day for CBOD and TSS, respectively).

5.4.3 Irwin Creek WWTP

Figure 5-9 shows a modest decrease in flows by nearly 1-mgd in three years. Loading rates for CBOD and TSS have remained steady at approximately 21,000 dry pounds per day range.

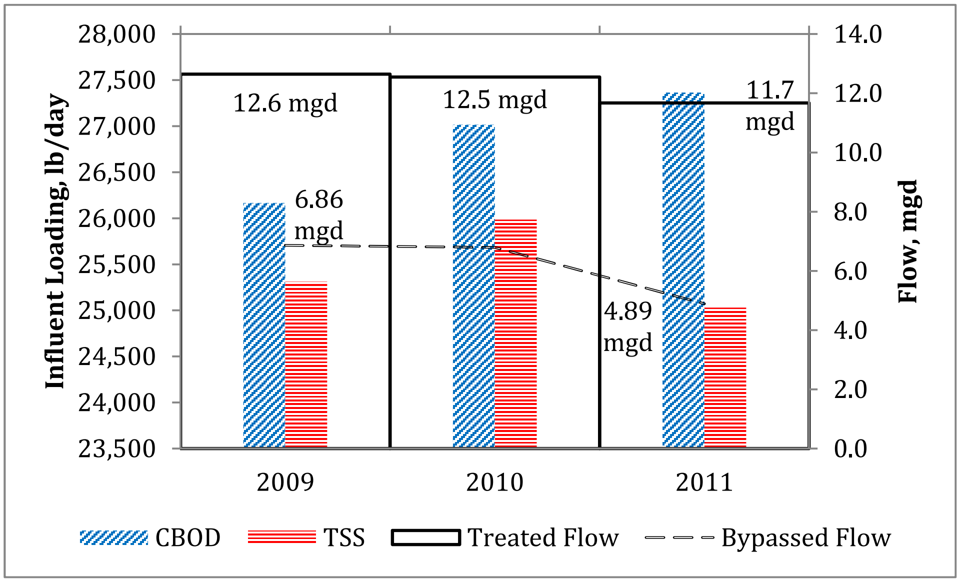

Figure 5-8
Sugar Creek WWMF – Annual Influent Flow and Loadings

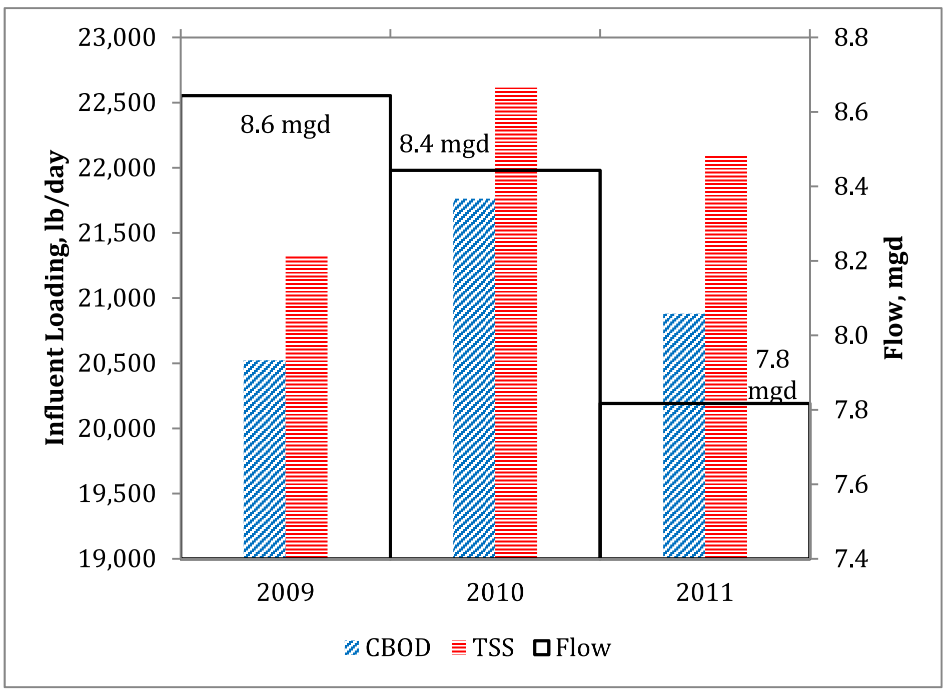

Figure 5-9
Irwin Creek WWTP – Annual Influent Flow and Loadings

5.4.4 Mallard Creek WRF

As shown in **Figure 5-10**, Mallard Creek WRF flows have experienced a slight decrease in year 2010 but have remained in the 8-mgd range between year 2009 and year 2011. While CBOD has steadily increased from 17,200 to 18,300 dry pounds per day, TSS have decreased by nearly 2,500 dry pounds per day. This suggests that the solids composition may have slowly changed, with an increased percentage of organic compounds, or that more soluble BOD is available in the wastewater.

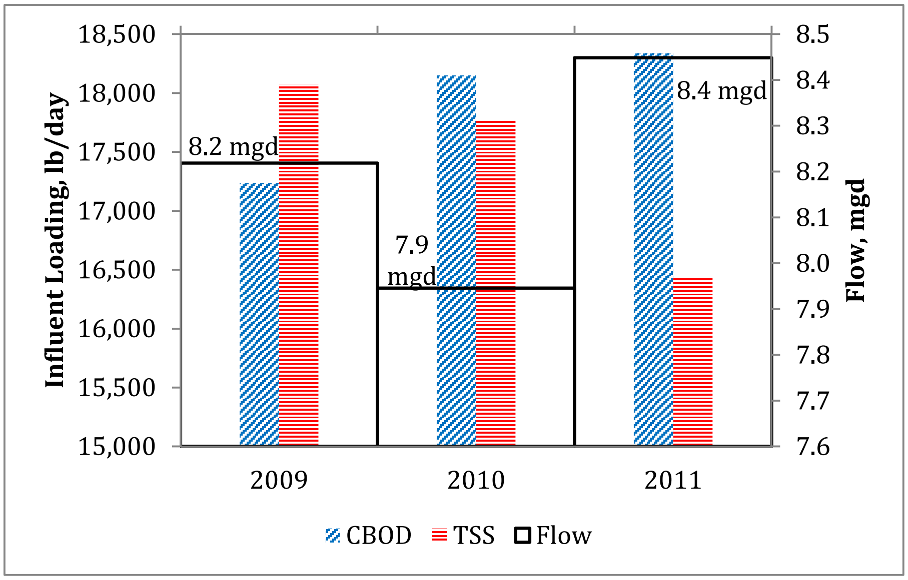

Figure 5-10
Mallard Creek WWTP – Annual Influent Flow and Loadings

5.4.5 McDowell Creek WRF

As shown in **Figure 5-11**, flows at McDowell Creek WRF have remained stable. CBOD has steadily increased from 10,000 to 11,000 dry pounds per day; while TSS have remained at 11,500 dry pounds per day in years 2009 and 2011 with a dip to 10,000 dry pounds per day in year 2010.

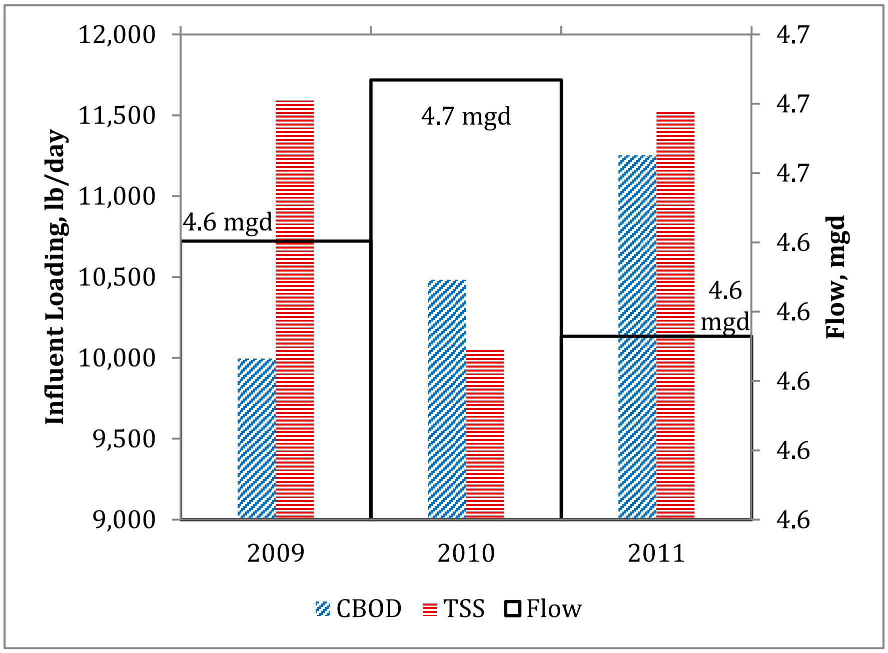

Figure 5-11
McDowell Creek WRF – Annual Influent Flow and Loadings

5.5 Historical Operations Data

Historical data for critical parameters were obtained from daily operations summaries at each facility and were checked against the results of the mass balance of the solids process. When parameters required for this analysis were not available from daily records, they were estimated based on the results of the mass balance. The mass balance was calibrated to correlate to observed disposal quantities of biosolids, as reported by Synagro.

For the McAlpine Creek WWMF, the analysis summarized in **Table 5-8** evaluates two separate primary and secondary treatment trains, the North and South Plants, and does not include loadings from Sugar Creek WWTP treated at this facility. **Table 5-9** presents primary clarifier solids and WAS generated at Sugar Creek WWTP currently transferred to McAlpine Creek WWMF for further processing. Historical operations data for the remaining WWTPs are shown in **Table 5-10** through **Table 5-12**.

Table 5-8 McAlpine Creek WWMF Historical Operations Data (2009-2011)

Parameter	Solids Production (Dry Tons per Day)			Unit Solids Production (Dry Tons per Mgal Treated)			Peaking Factor	
	Annual Average Day	Max Month	Max 2-Week	Annual Average Day	Max Month	Max 2-Week	Max Month	Max 2-Week
Primary Clarifier Solids								
North Plant	14.3	20.0	20.6	0.31	0.43	0.45	1.40	1.44
South Plant	16.1	22.6	23.3	0.35	0.49	0.50	1.40	1.44
Total	30.4	42.6	43.9	0.66	0.92	0.95	1.40	1.44
WAS								
North Plant	12.9	15.9	16.5	0.28	0.35	0.36	1.24	1.28
South Plant	14.5	21.5	22.5	0.31	0.47	0.49	1.48	1.55
Total	27.4	37.5	39.0	0.59	0.81	0.85	1.37	1.42
Total Solids Production								
Total Solids Production	57.9	80.1	82.9	1.25	1.74	1.80	1.38	1.43

Table 5-9 Sugar Creek WWTP Historical Operations Data (2009-2011)

Solids Production (Dry Tons per Day)			Unit Solids Production (Dry Tons per Mgal Treated)			Peaking Factor	
Annual Average Day	Max Month	Max 2-Week	Annual Average Day	Max Month	Max 2-Week	Max Month	Max 2-Week
Primary Clarifier Solids							
7.4	9.5	9.9	0.61	0.77	0.81	1.27	1.33
WAS							
5.0	6.7	7.4	0.41	0.55	0.60	1.33	1.46
Total Solids Production							
12.5	16.2	17.3	1.02	1.31	1.40	1.29	1.38

Table 5-10 Irwin Creek WWTP Historical Operations Data (2009-2011)

Solids Production (Dry Tons per Day)			Unit Solids Production (Dry Tons per Mgal Treated)			Peaking Factor	
Annual Average Day	Max Month	Max 2-Week	Annual Average Day	Max Month	Max 2-Week	Max Month	Max 2-Week
Primary Clarifier Solids							
6.4	7.3	7.6	0.8	0.88	0.91	1.15	1.19
WAS							
4.0	5.4	5.7	0.5	0.65	0.69	1.37	1.45
Total Solids Production							
10.3	12.7	13.3	1.2	1.53	1.60	1.23	1.29

Table 5-11 Mallard Creek WRF Historical Operations Data (2009-2011)

Solids Production (Dry Tons per Day)			Unit Solids Production (Dry Tons per Mgal Treated)			Peaking Factor	
Annual Average Day	Max Month	Max 2-Week	Annual Average Day	Max Month	Max 2-Week	Max Month	Max 2-Week
Primary Clarifier Solids							
4.7	5.6	5.7	0.6	0.7	0.7	1.20	1.23
WAS							
3.1	3.9	3.8	0.4	0.5	0.5	1.27	1.26
Total Solids Production							
7.7	9.5	9.6	0.9	1.2	1.2	1.23	1.24

Table 5-12 McDowell Creek WRF Historical Operations Data (2009-2011)

Solids Production (Dry Tons per Day)			Unit Solids Production (Dry Tons per Mgal Treated)			Peaking Factor	
Annual Average Day	Max Month	Max 2-Week	Annual Average Day	Max Month	Max 2-Week	Max Month	Max 2-Week
Primary Clarifier Solids							
3.4	4.2	4.4	0.7	0.9	1.0	1.23	1.29
WAS							
4.0	4.9	5.1	0.9	1.1	1.1	1.23	1.29
Total Solids Production							
7.4	9.0	9.5	1.6	2.0	2.1	1.23	1.29

5.6 Projected Solids Production

Future solids production was calculated by multiplying primary solids and WAS estimates (in dry tons per Mgal of wastewater treated) by projected wastewater flows up to year 2035.

5.6.1 Sugar Creek WWTP

As shown in **Table 5-13**, future wastewater flows processed at Sugar Creek WWTP are assumed to correspond to the plant's capacity, limited to 13-mgd in year 2022 due to phosphorus discharge limits and to 16-mgd following a plant expansion in year 2022.

Table 5-13 Sugar Creek WWTP – Future Solids Production

Year	Annual Average Flow (mgd)	Primary Clarifier Solids (Dry Tons per Day)		WAS (Dry Tons per Day)		Total Solids Production (Dry Tons per Day)	
		Annual Average Day	Max Month	Annual Average Day	Max Month	Annual Average Day	Max Month
2015	13.0	7.9	10.0	5.3	7.1	13.2	17.1
2020	13.0	7.9	10.0	5.3	7.1	13.2	17.1
2025	16.0	9.7	12.3	6.6	8.7	16.2	21.0
2030	16.0	9.7	12.3	6.6	8.7	16.2	21.0
2035	16.0	9.7	12.3	6.6	8.7	16.2	21.0

5.6.2 McAlpine Creek WWMF

McAlpine Creek WWMF was assumed to experience an annual rate of increase in wastewater flows of 1.5 percent. **Table 5-14** summarizes future solids production at this facility, excluding primary solids and WAS transferred from Sugar Creek WWTP. The total solids treated at McAlpine Creek WWMF (including loadings from Sugar Creek WWTP) are instead presented in **Table 5-15**.

Table 5-14 McAlpine Creek WWMF (North/South Plant Only) – Future Solids Production

Year	Annual Average Flow (mgd)	Primary Clarifier Solids (Dry Tons per Day)		WAS (Dry Tons per Day)		Total Solids Production (Dry Tons per Day)	
		Annual Average Day	Max Month	Annual Average Day	Max Month	Annual Average Day	Max Month
2015	48.8	32.2	45.1	18.5	26.0	50.8	71.1
2020	46.4	30.6	42.9	17.6	24.7	48.3	67.6
2025	50	33.0	46.2	19.0	26.6	52.0	72.8
2030	53.9	35.6	49.8	20.5	28.7	56.1	78.5
2035	58.3	38.5	53.9	22.2	31.0	60.6	84.9

Table 5-15 McAlpine Creek WWMF (with Sugar Creek WWTP Solids) – Future Solids Production

Year	Annual Average Flow (mgd)	Primary Clarifier Solids (Dry Tons per Day)		WAS (Dry Tons per Day)		Total Solids Production (Dry Tons per Day)	
		Annual Average Day	Max Month	Annual Average Day	Max Month	Annual Average Day	Max Month
2015	48.8	40.1	55.1	23.9	33.1	63.9	88.1
2020	46.4	38.5	52.9	23.0	31.8	61.5	84.7
2025	50.0	42.7	58.5	25.6	35.3	68.2	93.8
2030	53.9	45.3	62.1	27.0	37.4	72.3	99.5
2035	58.3	48.2	66.2	28.7	39.8	76.9	105.9

5.6.3 Irwin Creek WWTP

Future solids production at the Irwin Creek WWTP is based on the assumption that wastewater flows from various sources (such as Long Creek pump station, Town of Belmont and Paw Creek pump station) will be treated at this facility in the future. The future solids production for Irwin Creek WWTP is shown in **Table 5-16**.

Table 5-16 Irwin Creek WWTP – Future Solids Production

Year	Annual Average Flow (mgd)	Primary Clarifier Solids (Dry Tons per Day)		WAS (Dry Tons per Day)		Total Solids Production (Dry Tons per Day)	
		Annual Average Day	Max Month	Annual Average Day	Max Month	Annual Average Day	Max Month
2015	8.5	6.5	7.5	4.0	5.5	10.5	13.0
2020	11.8	9.0	10.4	5.6	7.7	14.6	18.1
2025	12.4	9.5	10.9	5.9	8.1	15.4	19.0
2030	13.0	9.9	11.4	6.2	8.5	16.1	19.9
2035	13.5	10.3	11.9	6.4	8.8	16.8	20.7

5.6.4 Mallard Creek WRF

Due to the absence of available flow projections for Mallard Creek WRF, forecasted solids production at this facility is based on two growth scenarios. The moderate and aggressive scenarios represent a 0.8 and 1.8 percent rate of annual increase in wastewater flows, as reflected in **Table 5-17** and **Table 5-18**. The resulting difference in total max month solids loadings for the two scenarios corresponds to approximately 3-mgd in year 2035.

Table 5-17 Mallard Creek WRF – Future Solids Production (Moderate Growth Scenario)

Year	Annual Average Flow (mgd)	Primary Clarifier Solids (Dry Tons per Day)		WAS (Dry Tons per Day)		Total Solids Production (Dry Tons per Day)	
		Annual Average Day	Max Month	Annual Average Day	Max Month	Annual Average Day	Max Month
2015	8.5	4.8	5.8	3.2	4.0	8.0	9.8
2020	8.9	5.0	6.1	3.3	4.2	8.4	10.3
2025	9.2	5.2	6.3	3.4	4.3	8.6	10.6
2030	9.5	5.4	6.5	3.5	4.5	8.9	11.0
2035	9.8	5.6	6.7	3.6	4.6	9.2	11.3

Table 5-18 Mallard Creek WRF – Future Solids Production (Aggressive Growth Scenario)

Year	Annual Average Flow (mgd)	Primary Clarifier Solids (Dry Tons per Day)		WAS (Dry Tons per Day)		Total Solids Production (Dry Tons per Day)	
		Annual Average Day	Max Month	Annual Average Day	Max Month	Annual Average Day	Max Month
2015	8.7	4.9	5.9	3.2	4.1	8.2	10.0
2020	9.5	5.4	6.5	3.5	4.5	8.9	11.0
2025	10.4	5.9	7.1	3.9	4.9	9.8	12.0
2030	11.4	6.5	7.8	4.2	5.4	10.7	13.1
2035	12.4	7.0	8.4	4.6	5.9	11.6	14.3

5.6.5 McDowell Creek WRF

No wastewater flow projections are available for the McDowell Creek WRF. Solids production projection at this facility is based on a 1.0 percent rate of increase in wastewater flows, as summarized in **Table 5-19**.

Table 5-19 McDowell Creek WRF – Future Solids Production

Year	Annual Average Flow (mgd)	Primary Clarifier Solids (Dry Tons per Day)		WAS (Dry Tons per Day)		Total Solids Production (Dry Tons per Day)	
		Annual Average Day	Max Month	Annual Average Day	Max Month	Annual Average Day	Max Month
2015	4.8	3.5	4.4	3.2	4.0	6.8	8.3
2020	5.1	3.8	4.6	3.4	4.2	7.2	8.9
2025	5.3	3.9	4.8	3.6	4.4	7.5	9.2
2030	5.6	4.1	5.1	3.8	4.6	7.9	9.7
2035	5.9	4.4	5.4	4.0	4.9	8.3	10.3

5.6.6 Long Creek WWTP

The Long Creek WWTP is expected to come online in year 2020, treating wastewater flows from Long Creek pump station previously discharged to Irwin Creek WWTP and from the City of Mount Holly. The primary and secondary solids projections in **Table 5-20** are based on the assumption that the loading characteristics for Long Creek WWTP will be similar to those for Irwin Creek WWTP.

Table 5-20 Long Creek WWTP – Future Solids Production

Year	Annual Average Flow (mgd)	Primary Clarifier Solids (Dry Tons per Day)		WAS (Dry Tons per Day)		Total Solids Production (Dry Tons per Day)	
		Annual Average Day	Max Month	Annual Average Day	Max Month	Annual Average Day	Max Month
2020	7.5	5.7	6.6	3.6	4.9	9.3	11.5
2025	7.9	6.0	7.0	3.8	5.2	9.8	12.1
2030	8.3	6.3	7.3	4.0	5.4	10.3	12.7
2035	8.7	6.7	7.7	4.1	5.7	10.8	13.3

5.7 Conclusions

Current and projected solids production from year 2015 to year 2035 was estimated on the basis of current solids characteristics and wastewater flow projections at each WWTP. Primary and secondary solids loading rates were obtained from daily records between year 2009 and year 2011, when available, or from the results of a mass balance calculations calibrated against disposal data reported by Synagro.

Section 6

Opportunities for Reusing Class A Biosolids Within the Carolina Region

6.1 Introduction

CMUD is considering a long-term strategy of upgrading biosolids processing to produce a Class A product suitable for distribution to fertilizer manufacturers, biosolids brokers, or marketing to end-consumers. CMUD has an active contract with an independent contractor, Synagro, to manage disposal of Class B biosolids. The Synagro contract provides options for composting, lime stabilization, land application, and landfill disposal. Currently land application is the predominant measure used by Synagro followed by landfill disposal which is used when conditions are not appropriate for land application due to weather, storage capacity limitations and/or when biosolids do not conform with land application criteria. There are currently 10,600 net acres permitted in North Carolina and 7,439 net acres permitted in South Carolina for land application. Approximately 4,000 acres are utilized annually for land application. CMUD has both a Class A and Class B permit in North Carolina and a Class B permit in South Carolina. No production of Class A products from composting or lime stabilization is currently conducted by Synagro due to costs and handling requirements associated with these production operations.

Interest in Class A products, as defined in Part 503, has increased in recent years. This interest is linked to identifying approaches to address key issues facing beneficial reuse/land application and disposal of biosolids which include:

- Urbanization - decline of local permitted acreage contributing to longer travel distances to land application sites and associated higher costs.
- Negative public sentiment relating to land application in certain locations.
- Increasing costs of landfill disposal.

Given these conditions and uncertainties, diversified use/disposal strategies with multiple outlets should therefore be considered. Class A biosolids potentially offer a value-added product that can be distributed and marketed, and generally has shown to be more accepted by the general public than Class B residuals. A Class A pelletized product provides diversity of use and enables more sustainable and lower risk reuse options.

The production and end use of a Class A product needs careful consideration. Product quantity, quality, marketability, cost of implementation are a few of the key factors that must be evaluated to determine the need and timing for cost-effective implementation.

This section presents the results of an end-user survey aimed at identifying the various reuse opportunities for a Class A biosolids pelletized product. End users from the following categories were asked to respond to questions from a standard survey:

- Fertilizer Blenders/Manufacturers

- Biosolids Brokers
- Garden Centers
- Golf Courses
- Landscape Contractors
- Sod Growers/Turf Farms
- Vegetable/Fruit Growers

Greater focus was placed on bulk sales to the agricultural industry and to regional fertilizer blenders (those that produce both agricultural and horticultural fertilizers). End users expressed their degree of interest in Class A biosolids by providing qualitative anecdotal information.

6.2 Product Characteristics and Typical Uses

This Master Plan evaluates various Alternative management strategies that offer the advantage of achieving Class A biosolid product. Discussed below are quality-related considerations used to substantiate the recommendation that CMUD progress to establishing a higher level of treatment. This section reminds readers of the various advantages afforded to biosolids producers of Class A product.

6.2.1 Heat-Dried Pellets

Pellet quality depends on a number of factors, such as: nutrient content, size uniformity, dust content, spreadability, rate of nutrient release, odors, and bulk density (percent solids). Many heat-dried biosolids products have a nitrogen content of 4-6 percent which is lower than the most extensively used commercial fertilizers. The digestion process is responsible for the reduction in nitrogen, though, digestion is a critical step, particularly for high-end applications, because it reduces odor in the final product.

Marketability and end uses depend on product quality. Uniform, hard spherical pellets can be used as a base in commercial fertilizer blends or directly land applied. Smaller diameter pelletized products are especially popular among golf course turf superintendents, athletic field maintenance staff, and homeowners, because they provide organics and a slow release form of nitrogen which will not burn sensitive turf and plants. Also, these products can be applied using conventional fertilizer spreaders. Lower quality pellet products have reduced distribution and use and are normally applied to agricultural fields or other horticultural applications where dust and spreadability may be less of an issue.

Pelletized products are usually distributed in bulk or bag form. Prices are based primarily on nitrogen (N) content which are currently about $3 - $4 per percent N per ton; although prices as high as $10 per percent N per ton have been reported for high end pellet products. Because of their economic value and high bulk density, pellet products can be transported greater distances economically. For example, a popular product from Wisconsin, Milorganite, is marketed across the nation, including by major retailers in the Carolinas. The product sells for $14-18 for a 50 lb. bag in retail centers and has a nutrient analysis of 5-2-0 (N-P-K).

6.2.2 Digested/Dewatered Biosolids

Beneficial use of Class A digested and dewatered biosolids is typically accomplished through land application to agricultural land with similar restrictions as Class B dewatered biosolids. Class A stabilized product is, however, substantially more publically acceptable and has more diverse end-use opportunities. For example, Class A product may be used by sod farms to replenish soil after turf harvest. Class A stabilized product is marketable to top-soil producers that bag their product for sale at major home and garden retailers. Class A biosolids may also be readily be used as valuable landfill cover across the Carolinas.

6.2.3 Nutrient Content

The nutrient content of biosolids and other fertilizers is usually described as "N-P-K" value, which relates to the dry weight of nitrogen (N), available phosphoric acid (P), and potassium (K), respectively, as percentages of total dry weight of product. Accordingly, fertilizer prices are often based on the nitrogen content, with high nitrogen products commanding the higher prices in the market. Unlike other fertilizers, biosolids introduce nitrogen and phosphorus in organic forms that are more accessible for plants and less likely to leach away from the plant's root zone (i.e. into ground and surfaces waters). Given the extent to which phosphorus leaching is a growing environmental concern, pelletized biosolids offer a form a phosphorus that has lower potential for adverse environmental impacts, thereby increasing its marketability. On the other hand, the ratio of nitrogen to phosphorus in terms of plant needs is such that an application rate of biosolids to meet plant nitrogen needs may result in the over-application of phosphorus to the soil. Generally, the nutrient content of pelletized biosolids is low compared to commercial fertilizers. An exception to this is fertilizer blenders/distributors that use dried biosolids products as a component of a blended product. Unlike mineral-based fillers, biosolids contribute to the fertilizer's nitrogen and phosphorus content and, most importantly, deliver natural organic matter, which has the following benefits:

- Improved soil structure- biosolids can greatly enhance the physical structure of soil, reducing its erosion potential.
- Improved drought resistance- increased organic matter provided through biosolids can increase water retention, improving drought resistance and promoting efficient water utilization.
- Increased Cation Exchange Capacity (CEC) - an increased CEC improves plants' ability to more effectively utilize nutrients and reduces nutrient losses and metal solubilization through leaching.
- Enhanced soil biota- the activity of soil organisms is essential in productive soils and for healthy plants. Their activity is largely based on the presence of organic matter, which can be provided through biosolids applications.

6.3 End-User Questionnaire and Survey

To assess the current market and potential future markets for Class A biosolids products, information was obtained through a limited survey of businesses in North Carolina and South Carolina. This section summarizes the results of this survey. A copy of the questionnaire is included in Appendix C. **Table 6-1** lists all of the potential end-users that were contacted.

Table 6-1 Survey Participants Representing Various End-User Groups

Survey Participants	
Industry	**Company Name**
Golf Course Maintenance	RatCliffe Golf Services Inc.,
	Carmel Country Club
	Piper Glen Country Club
Fertilizer Manufacturer/Distributor	Harolds Fertilizer
	Howards Fertilizer
	Southern States Fertilizer
	Protech Environmental Supply
Biosolids Broker	Synagro
	SoilPlus
Nursery/Greenhouse	Campbells
Agricultural Farmer	Carolina Organic
Turf Farmer	Super Sod, Hendersonville, NC
	Super Sod, Orangeburg, SC

6.3.1 Golf Courses

Golf courses are heavy users of fertilizers and soil conditioners. Typically, both organic and inorganic products are used to maintain optimum course conditions and appearance. In recent years, there has been a tendency to replace some of the inorganic fertilizers with organic products, potentially increasing the market for biosolids in this sector. The golf course market is traditionally skeptical of new or different products, and their primary concerns tend to be particle size, solubility, and spreadability. Heat-dried pellets are a potential product for golf courses.

In particular, grounds-management programs that have experience with Milorganite expressed support for the prospect of an equivalent product offered locally in NC. They noted that their patrons/members have not complained in the past of odors related to the use of Milorganite. One superintendent noted that using biosolids as a soil amendment has been proven to be an effective deterrent to deer that come onto the course and damage the greens and surrounding plant beds.

6.3.2 Fertilizer Manufacturers

Fertilizer manufacturers provided a range of feedback. Some touted the benefits of using biosolids as the base of their product, such as the organic matter content and the contribution of nitrogen and phosphorus. Fertilizer companies in the NC region have been successful at selling Milorganite, a Class A pelletized product. They typically purchase the product for 10 dollars per 50 pound (lb) bag, and, after blending processes, sell it for $15 dollars per 50 lb bag. Southern States Fertilizer, a local company, sells 30 tons of their biosolids-incorporated fertilizer blend in a 150 miles radius sales region located in western NC and northern SC. The majority of their sales, like most plant/crop growers, occur in the spring and fall seasons. In order for biosolids to be marketed to fertilizer manufacturers/blenders it should meet the following criteria:

- Be cost-competitive with traditional fertilizer inputs.
- High bulk density (low moisture content).

- Low heavy metal content (by RCRA standards).
- Minimal odors.
- Minimal "dusty" character.

6.3.3 Biosolids Broker

SoilPlus, located in Greenville, NC, collects Class A biosolids from WWTPs and provides compensation to an amount proportional to the product's quality and level of treatment. Such "brokers" distribute to a wide variety of end-users, including:

- Farmers
- Plant nurseries
- Turf growers
- Pulp and paper mills
- Cement kilns
- Incinerators

SoilPlus holds the responsibility for land-application permitting and is capable of registering their product as USDA-certified fertilizer. SoilPlus offers a product outlet that is not vulnerable to seasonal changes in demand by maintaining off-site storage capacity during seasons of lower demand.

6.3.4 Agricultural Industry

Many farms utilize compost or digested biosolids as a soil conditioner and erosion control agent, as well as pelletized products as fertilizer. Organic farmers surveyed are more likely to use composted animal manure because of the concerns of heavy metals and pharmaceuticals in wastewater-derived biosolids. Farmers in NC were generally more supportive of biosolids-derived fertilizers than their South Carolina counterparts.

In order for biosolids product to be competitive in the agricultural market it needs to meet the same criteria listed above for fertilizer manufacturers. Odorous biosolids have resulted in complaints from residents living adjacent to the farm where the biosolids are applied. The product must also be "spreadable" and compatible with the existing application equipment.

6.3.5 Sod/Turf Farming

Sod farming is another large user of soil amendment, which could include compost, pelletized product, and/or digested biosolids/dewatered product. Most grasses will thrive on soil with biosolids added as top dressing or mixed into the soil. The establishment and maintenance of grasses is a major horticultural activity in the Carolinas, which rivals agriculture when one considers the labor, equipment, and fertilizers involved.

One South Carolina-based sod farmer rejected the idea of using biosolids-containing fertilizer because of the perceived pathogenicity and the danger of tracking biosolids into homes on one's shoes. This perception highlights the need for a wide-reaching educational component to supplement any CMUD strategy to market and distribute its biosolids.

6.3.6 Nursery/Greenhouse

Campbell's plant nursery, located in Charlotte, revealed during the survey that, as a locally supported business, they are very supportive of the use of Class A pellets in nursery/greenhouse operations. In addition to using the fertilizer to promote the growth of the plants they sell, greenhouses also attract "green"-consumers who buy the bagged fertilizer directly. Campbell's nursery sells 4-lb bags of fertilizer for $6 each. They noted their customers' potential concern of pathogenicity, metals and pharmaceuticals content in the biosolids-derived fertilizer. Such public perception concerns should be addressed through an educational program led by a marketing consultant.

6.4 Conclusions of the Survey of Biosolids Reuse Opportunities in the Carolinas

A survey of potential users of Class A biosolids was conducted to gauge the strength of the possible reuse opportunities for CMUD produced Class A product in its biosolids management program. The following conclusions are presented from the results of the survey:

- The marketability of the biosolids product is dependent on its ability to compete with commercially available fertilizers and soil amendments.
- A pelletized product use in NC and SC appears to have a variety of applications and use opportunities, including golf courses, plant nurseries, agricultural and turf farming industries.
- Broad education efforts to address public concerns are critical and most likely should be handled by marketing consultants.
- Brokers, large blenders and/or distributors could be used for Class A pellet management to take advantage of their ability to store, blend and transport products to adapt to market demands and maintain a stable supply chain.
- For planning purposes, CMUD should assume little or no revenue from Class A pellet product; however the quality distinction is conducive to distribution to a greater variety of end users.

Section 7

Current and Emerging Biosolids Regulations

This section presents a summary of existing federal and state regulations, as well as national and local trends affecting management practices for final disposal of biosolids and water treatment residuals. This analysis will serve as a framework for future management strategies evaluated for the water and wastewater treatment facilities owned and operated by CMUD.

7.1 Emerging Issues

As required by the Clean Water Act (CWA) Amendments of 1987, EPA developed Title 40 of the Code of Federal Regulations (CFR) Part 503, or 'Part 503 Rule', which was promulgated in 1993 and amended in 1994. This Rule defines the requirements for biosolids prior to land-application, surface disposal and incineration. For each regulated use or disposal practice, Part 503 identifies general requirements, pollutant limits, management practices, operational standards, required frequency of monitoring, record keeping and reporting.

Since its promulgation in 1993, Part 503 regulations have not undergone major revisions. In 1993 and 2000 the Environmental Protection Agency (EPA) commissioned the National Academy of Sciences (NAS) to review the Part 503 rule. These studies focused on the potential link between land-applied biosolids and adverse human health effects. The subsequent reports, released in 1996 and 2002, confirmed that the practice is safe when regulations are followed. In 2003 the EPA developed a comprehensive action plan to address the concerns presented in the NAS report.

7.1.1 Microconstituents

The only major action that EPA has taken in the past 20 years with regards to possibly revising Part 503 concerned the possibility of including restrictions on maximum allowable concentrations of dioxins and dioxin-like compounds. These compounds are considered as representing a "worst case" organic wastewater pollutant due to their persistence in the environment and the toxic effect they can have on both humans and ecosystems. After extensive research, EPA found no significant risk warranting regulation of dioxins in sewage sludge that is managed by surface disposal or incineration.

More recent concerns have emerged about the presence of a large variety of other organics, such as those found in personal care products and pharmaceuticals. Often called "microconstituents," they have been linked to endocrine system abnormalities in animals even when introduced in small concentrations. Recent research has focused on impacts of these chemicals to aquatic ecosystems downstream of wastewater treatment facilities and, to a lower extent, to their effects on biosolids land application. Traces of the compounds of concern (in parts per billion or low parts per million concentrations) have been found in the soil after land application, as well as presence of chemicals into plant tissue after high concentrations of contaminants had been introduced into the soil. However, to date, there is no evidence to support significant negative impacts, chronic or acute, to plants and animals that were exposed to biosolids due to land application.

EPA's Office of Science and Technology (OST) has been responsible for conducting the biennial reviews and develop the Targeted National Sewage Sludge Survey (TNSSS) to identify which chemicals are present in sewage sludge and obtain national estimates of their concentrations. The sampling effort provided results for 145 chemicals that have been identified as "emerging contaminants of concern." The results of the TNSSS report were published in 2009 and since then EPA has continued to collect data on these pollutants in order to conduct risk assessments.

EPA does not currently have sufficient exposure or toxicity data to develop numeric limits and management practices for many of the 145 pollutants of concern. Ten of the contaminants measured by the TNSSS, including molybdenum, have been classified by EPA as in need of further risk evaluation, the results of which may affect future changes in land application requirements promulgated by EPA. In particular, it is possible that a numeric Table 3 (EQ Biosolids) limit of 40 mg/kg may be required for molybdenum, which is currently limited to a Table 1 ceiling concentration standard of 75 mg/kg in biosolids destined for land application.

7.1.2 Pathogen Reduction Alternatives

Another potential change to Part 503 that could occur in the future is the elimination of pathogen reduction alternatives 1 and 2 for Class B and 3 and 4 for Class A biosolids. Biosolids producers would no longer be allowed to demonstrate pathogen reduction based on the practice of testing and monitoring for indicator pathogens (Salmonella sp. bacteria and fecal coliform). Instead, facilities would have to adopt treatment procedures that have been approved by EPA based on their pathogen reduction capacity. For more detail on these treatment procedures, readers may refer to Control of Pathogens and Vector Attraction in Sewage Sludge (EPA/625/R-92/013), published in December 1992.

The analytical methods section of the rule does not currently include modern techniques that are widely used and relied upon by biosolids management practitioners. Though the practices do not technically meet compliance requirements, EPA ignores this discrepancy and intends to update the section in the future. The only portion of the rule that has been updated at this time is with regards to methods for analyzing fecal coliform and salmonella.

The EPA Office of Research and Development (ORD) will continue to research various biosolids-related topics, such as: the presence of endotoxin in biosolids, characterization studies, improved indicators for pathogens, fate and transport studies, and the use of bioassays to asses potential impacts from biosolids land application. A timeframe for rule updates is, however, unknown and it appears unlikely that additional changes to Part 503 will occur in the immediate future.

7.1.3 Air and Radiation Regulations Affecting Wastewater Solids

In 2011, the U. S. EPA Office of Air and Radiation created new rules regulating sewage sludge incinerators (SSI). It is however anticipated that they will not affect future management strategies at CMUD, as it is unlikely that incineration will be considered as a technology of choice. The new SSI regulations declared that sewage sludge that is combusted is considered a solid waste under Section 129 of the CAA, rather than under the less stringent Section 112, in accordance with the development of Maximum Achievable Control Threshold (MACT) numerical standards for SSI's.

With this change in the definition of sludge, EPA disputes that sewage does not meet 'legitimacy criteria' for renewable fuel, which may affect other biosolids management practices that aim at combusting biosolids to recover energy. States are required to submit plans to the EPA that described the regulations the state would need to develop in order to enforce the new standards. This regulatory shift may increase the costs associated with incineration as a biosolids management strategy. SSIs that cannot comply with the new standards by 2017 will be forced to cease operations, thus increasing the biosolids supply regionally.

The U.S. EPA Office of Air and Radiation has taken a greater interest in the greenhouse gas (GHG) emissions from large industrial facilities. Facilities that emit levels of GHGs above a prescribed threshold must adhere to reporting requirements. Wastewater treatment facilities do not, in most cases, exceed the reporting threshold. The Agency is also addressing GHGs in under the existing Title V and Prevention of Significant Deterioration (PSD) standards. The decision to incorporate biogenic GHG emission thresholds into these standards has been postponed until 2014. Large wastewater treatment facilities will face unique challenges if future regulations include limits to biogenic GHGs.

7.1.4 Nutrient Management

The responsibility of regulating biosolids is held primarily by the EPA at the federal level; however, other federal agencies are involved by means of interagency agreements with EPA. The U.S. Department of Agriculture (USDA) and the Food and Drug Administration (FDA) provide guidance for the management of biosolids used on soils and in the production of food crops. These agencies are primarily concerned with nutrient management practices and protecting organic crops from the introduction of synthetic chemicals during land application of biosolids. For example, the Department of Health and Human Services' National Institute for Occupational Safety and Health (NIOSH) published a guidance manual in 2002 focusing on the risk of worker exposure to Class B Biosolids.

It is unlikely that these agencies' involvement in biosolids regulations will significantly affect wastewater treatment facilities and their future biosolids management strategies. Nutrient management, however, could be a factor that affects biosolids producers at the state and local level in the future. As public awareness has increased with regards to nutrient management, USDA reports and guidance have discussed the effects of biosolids along with fertilizers and manure. For example, the December 2011 Natural Resource Conservation Service 590 guidance on nutrient management, presents detailed information on biosolids management on farms and suggests the need for increased emphasis on controlling phosphorus levels in soils subject to land application.

7.2 State Regulatory Trends

North Carolina and South Carolina regulate biosolids according to rules enacted within each state that are at least as restrictive as those regulations put forth by the federal Part 503 Rule. The EPA has significantly reduced their funding allocations to biosolids regulators and research efforts. This condition reinforces the position that new limits or management conditions for constituents like molybdenum or chromium aren't expected any time soon.

There are few differences between the States' and federal regulations but there are a few that are worth presenting as they may influence future trends in biosolids management and control. The following sections will describe a number of these differences.

Various states have implemented changes to their regulations on biosolids as they pertain to land application.

Texas requires both a permit and a public hearing for Class B land application, in addition to the implementation of a Nutrient Management Plan (NMP). As a result of this rule, land appliers in the state have decreased by 75 percent, and the total volume of biosolids has fallen 25 percent, due to the cost and uncertainties of the permitting process.

In Florida, where nearly two thirds of the biosolids are land applied, Class A and B land application in the Okeechobee region has been forbidden since 2008. Florida has recently increased regulatory requirements on lime stabilized products, specifying the maximum storage time of lime-stabilized biosolids on the soil surface prior to incorporation. This reflects state-level trends also seen in Ohio. Additional restrictions to Class B land application near Orlando and requirements on setbacks will apply once proposed changes take effect in 2013. NMPs will also be required for both Class A and Class B land application, and will incorporate phosphorus based management requirements.

Ohio and Washington have eliminated Alternatives 3 and 4 as Class A pathogen reduction options, and Vermont is also reportedly considering this change. This is due to the concern that meeting Class A pathogen content requirements for helminth ova and enteric viruses (defined in Class A Alternatives 3 and 4) may only demonstrate low concentrations of these organisms, not necessarily effectiveness of the treatment process in reducing pathogen content. A similar concern has also been raised with regards to fecal coliform associated to Class B Alternative 1 requirements. EPA agrees with these conclusions, noting that "without a defined treatment, the absence of specific organisms cannot be used to infer the absence of other potentially pathogenic organisms in the biosolids" and that "the treatment technology alternatives (i.e., Class A Alternatives 1, 2, 5, and 6, and Class B Alternatives 2 and 3) provide better and more consistent protective value from a human health standpoint than microbial testing in the absence of defined treatment."

7.2.1 North Carolina

Residuals and Biosolids Regulations

Under North Carolina General Statute, residuals are defined as waste, and any system that collects, treats, or disposes of waste cannot be constructed or operated without a permit. The statute authorizes the Environmental Management Commission (EMC) and the Department of Environment and Natural Resources (DENR) to develop and implement state regulations and issue permits for the generation and disposal of residuals. These functions are carried out by DENR's Division of Water Quality (DWQ).

DWQ Residuals Management Program regulates the treatment, storage, transportation, use, and disposal of residuals as specified in 15A NCAC 02T: Waste Not Discharged to Surface Waters. Rules specific to Residuals Management are located in Section .1100 of Subchapter 02T. The majority of residuals generated in North Carolina are land applied for beneficial use, with 260 permitted facilities for Class A and B residuals in 2009, and 15 facilities permitted for surface disposal only.

DWQ's Residuals Management Program provides requirements for use and disposal of residuals in accordance with the following strategies:

- Distribution of Class A residuals and Class B residuals to non-dedicated fields.
- Land application of residuals to dedicated fields.
- Surface disposal of residuals.

Examples of where North Carolina's program is more protective than the 40 CFR 503 requirements are:

- Additional setbacks from land application fields for increased protection of the State's water resources and of human health.

- Site specific agronomic loading rates based on crop realistic yield as determined by the North Carolina Department of Agriculture and Consumer Services.
- Requirements for monitoring wells on dedicated sites.
- Tracking transportation of biosolids products into North Carolina.

The State is generally supportive of land application of fertilizer-grade biosolids. Application of fertilizer grade product requires USDA approval following laboratory testing to provide guaranteed nutrient content.

Nutrient Management

Current agronomic application rates are based on realistic yield expectations (RYE) for crops matched to local soil classification in accordance with the North Carolina Department of Agriculture and Consumer Services. Application of residuals to non-dedicated fields must not exceed recommended agronomic rates for Nitrogen

Phosphorus loading to application sites accepting biosolids may be regulated in coming years. However there is no current directive for implementing control of phosphorus in residuals or biosolids in the near future.

Biosolids and Residuals Management Future Trends

A discussion of future trends in North Carolina was conducted with DENR representatives Ed Hardee and Jon Risgaard on February 20, 2013. Key points from our discussions include:

- New policies in biosolids management are not expected in the next 5-10 years.
- Any changes would be made over time to give utilities the chance to comply.
- North Carolina is trending toward less restrictive regulations in the coming decade. The State passed a ruling in 2011 to restrict the formation of any new rules that are more restrictive than current federal rules. State regulators are making efforts to reduce the limitations to land application of biosolids. One effort involves eliminating the current requirement of set-backs on every property line, even if the adjacent parcels have a common owner. The State's effort to correct this exemplifies its interest in alleviating restrictions to land application of biosolids.
- Currently, only dedicated sites (sites to which residuals are applied routinely and/or higher than agronomic rates) are required to maintain groundwater monitoring wells. Requirements for groundwater monitoring are not likely to expand because the current policies are viewed as sufficiently protective, and there is not public concern about negative impacts to drinking water sources.
- In 2009, North Carolina enacted an extension of coverage of certain government permits, including land application of biosolids and residuals (Session Law 2009-406). Any permits that were current and valid at any point between Jan. 1, 2008 and Dec. 31, 2010 were renewed under Chapter 23, Article 21 of the North Carolina General Statutes. Some permits for application to dedicated sites were extended 10 or 11 years in accordance with this rule. Additional dedicated site permits are unlikely to be issued in the coming years.

7.2.2 South Carolina

Residuals and Biosolids Regulations

The State of South Carolina Department of Health and Environmental Control (SC DHEC) regulates the land application of biosolids through water pollution control limits set forth by the Bureau of Water and in accordance with Regulation 61-9. The regulatory provisions contained in R61-9.122 and 124 implement the regulations established in the NPDES Program and Title 48 of the South Carolina Pollution Control Act in accordance with section 405 of the CWA. Treatment works treating domestic sewage (TWTDS) are required to submit Form 2S to DHEC.

Pollutant concentration limits, pathogen limits, and biosolids quality classifications, established in R.61-9.503 are equal to those laid out in 40 CFR 503. In fact, there are few differences the standards and rules set forth by the State of South Carolina and the Code of the Federal Registrar. In those cases where the regulations differ, those set forth by South Carolina are more restrictive than those established at the federal level.

Examples of where South Carolina's program is more protective than the 40 CFR 503 requirements are:

- Permits requirements for land application of Class A and Class B biosolids.
- Additional setback requirements for land application sites.
- Application rate limits based on agronomic loading as determined by the South Carolina Cooperative Extension.
- Separate rules for industrial sludge.
- Permit to distribute and market Class A pellets products produced outside the state of South Carolina.
- Selective requirement of groundwater monitoring wells to demonstrate the absence of groundwater pollution by nitrates introduced by land applied biosolids.
- Restrictions on the frequency of land application; 1 application per three year period, in some cases.
- Biosolids may not be land applied during weekends and federal holidays, in some cases.

Nutrient Management

A discussion of DHEC's Nutrient Management program was conducted with DHEC representatives Mike Montebello and Brenda Green on February 21, 2013. Concern was expressed that current regulations set forth by this program are not sufficiently protective of the State's groundwater sources. Unsafe levels of nitrate have been observed in certain areas. New and reissued permits are evaluated with this perspective in mind. Some land areas are simultaneously receiving manure, fertilizer, and biosolids without being required to document the combined nutrient loading rates.

Biosolids and Residuals Management Future Trends

Further discussion ensued concerning the future trends in biosolids management in South Carolina. Key points from the discussions include:

- With the exception of farmers, residents of South Carolina generally have a negative perception of the practice of land applying biosolids. The public opposition is predominantly localized in residential areas that are near to land application sites. Their main concerns focus on odors and a lack of understanding of how the program is managed.
- DHEC is making a concerted effort to require improved documentation of crop management plans, particularly on large land application projects. The agency is reviewing their permit database to ensure that the information it contains is up to date including parcel boundaries, crops receiving biosolids, total annual nutrient loading, and frequency of application. In the future, permit holders seeking reissue will be required to update such information as well as provide additional information that is required for NPDES permits.
- SC DHEC is not likely to make changes to the current regulations, though, increased implementation and enforcement is expected in the next 5 to 10 years.
- Exceedances of current phosphorus limits have not been observed. Further restrictions of this nutrient are not expected in the next 15 years.
- The State allows but does not support the sale of commercially certified fertilizer produced from biosolids (Class A pellets). If such a product were transported into the state, an annual report of such quantities and proof of the facility's Class A permit would be required. The Department has received public comment of support of Class A biosolids because of the higher level of treatment associated.

Section 8

Preliminary Screening of Management Strategies

8.1 Introduction

This section identifies several management strategies for residuals processing and beneficial use for the water and wastewater facilities owned and operated by CMUD. These strategies aim at achieving life-cycle cost-based, environmentally sound and publicly acceptable approaches to meet the short- and long-term residuals management needs up to year 2035.

Process descriptions and reviews of existing residuals handling equipment are provided for each WTP and WWTP in Sections 2 and 4 of this report, respectively.

The existing residuals management program has various limitations including:

- **Single disposal outlet** – Class B land application (except for non-conforming residuals that are landfilled) is the sole disposal option, involving a relatively high risk since there is concern of diminishing land availability due to urbanization and, in particular, public concerns about Class B biosolids.
- **Dependence on one independent contractor**- Considerable risk is involved in relying on an external party for managing 100% of the residuals in the event contractor becomes unable to meet contractual terms with CMUD in the future.
- **Relatively poor dewatering performance at WWTPs** – all WWTPs have challenges regarding dewatering, from low solids cake concentration to fecal coliform regrowth issues.
- **Lack of resource recovery** – For example, the existing WWTPs are not capable of generating power from digester biogas.
- **No Class A biosolids** - No production of Class A biosolids is currently available at CMUD operations
- **WTP On Site Dewatering Limitations** – Vest WTP and Lee S. Duke's WTPs have on site dewatering limitations. Liquid residuals from Vest WTP are hauled to Franklin WTP for dewatering. From Franklin WTP, the dewatered solids are hauled to Irwin Creek WWTP where they are stored prior to land application.

The management strategies presented in this section aim at addressing the limitations of the existing biosolids and residuals management program. The following key drivers were identified for the development of management strategies:

- Achieve long-term sustainability.
- Mitigate risk.
- Provide multiple distribution outlets for end product.

- React to potential future changes in environmental regulations.
- Consider public perception of treatment processes and residuals products.
- Consider potential resource recovery opportunities and optimization.
- Address the possibility for regionalization.

The strategies developed will therefore need to consider the long-term dependability and sustainability of land application and landfilling. In particular, the feasibility of Class B land application is of increasing concern. This is evident by the recent elevated public interest and concerns when the SC DHEC recently began accepting public comments on CMUD's application for permit renewal for Class B land application on more than 6,600 acres in York, Chester, Lancaster and Fairfield counties.

Interest in Class A products, as defined in Part 503, has gained momentum in recent years. Class A offers a value-added product that can be potentially distributed and marketed, and does not raise the same level of public concern as Class B biosolids when land applied.

Due to limited acreage available for land application of Class B biosolids and availability of landfills, diversified strategies with multiple outlets, including Class A, should be considered.

While some Class A biosolids products may command certain revenues, seldom will they result in profits although they may contribute to reduce overall costs and risks, and will increase the reliability of final disposal by means of diversifying the available outlets for the final product.

Resource recovery opportunities are also important factors to be considered, which offers several benefits including reduction in carbon footprint and greenhouse gases. Their implementation should be facilitated by the fact that anaerobic digestion, a key factor for many sustainable approaches to resource recovery and beneficial end use, is already present at all CMUD WWTPs.

Figure 8-1
Gravity Belt Thickener

An additional element for consideration at the WTPs relates to whether the residuals will be processed on site, transported to a consolidated processing location, or treated at the WWTPs.

8.2 Biosolids Processing Technologies

8.2.1 Gravity Belt Thickening

Gravity belt thickening (GBT) (**Figure 8-1**) is a solid-liquid separation process that relies on coagulation and flocculation of the solids in a dilute slurry as well as drainage of free water through an open-mesh filter belt. This technology is a low-energy process that provides three to five-fold reductions in volume with polymer addition, assuming the thickening equipment is operating within its design parameters. Therefore, O&M costs for GBTs are typically lower than other thickening technologies (such as rotary drum thickening, **Figure 8-2**).

Figure 8-2
Rotary Drum Thickening

8.2.2 Anaerobic Digestion

Anaerobic digestion has been used at WWTPs for many years to produce a stabilized biosolids product. Key components of an anaerobic digestion system include the reaction tank (digester), microorganisms, a mixing system and a heating system. The microbe-rich environment inside the digester is deprived of dissolved oxygen and nitrate to facilitate the conversion of volatile solids to digester gas and water. Egg-shaped digesters (as shown in **Figure 8-3**) are advantageous because they minimize scum formation and facilitate grit removal, though they are more costly to construct. Good performance can also be obtained from a less-expensive cylindrical design with a sloped floor.

Anaerobic digesters are typically designed to operate at either mesophillic (90-100 degrees F) or thermophillic (120-135 degrees F) temperatures and require tank mixing. According to 40 CFR Part 503, sewage sludge is considered a Class B biosolid with respect to pathogens if it meets the required minimum retention time of 15 days at 35-55 degrees C (95-131 degrees F). Vector attraction reduction requirements are fulfilled when volatile solids reduction in the sludge is at least 38 percent. A properly designed and operated digestion system will meet these criteria and produce biosolids suitable for land application.

Figure 8-3
Egg-Shaped Anaerobic Digesters

A useful byproduct of AD, digester gas, typically consists of approximately 65 percent methane and 35 percent carbon dioxide and has a heating value of 600 BTU/cubic foot. Energy available in the digester gas can be recovered and used to power a variety of processes including the digester sludge heating and thermal drying systems.

8.2.3 Thermal Hydrolysis

Thermal hydrolysis is a biosolids pre-treatment option that applies pressure and temperature to residuals prior to digestion. The thermal hydrolysis pretreatment (THP) conditions sludge by fracturing cellular material and long-chain fatty acids which makes the sludge more conducive to downstream digestion and dewatering processes. Coupled with downstream mechanical dewatering (e.g. belt filter presses, centrifuges) the digested biosolids can produce a cake that typically exceeds 30% total solids concentration. Prior to entering the THP, sludge must be dewatered. Once injected into the THP, solids are treated for about 30 minutes at 330 degrees F and 90 psi. These treatment conditions exceed those required by EPA 503 for producing Class A biosolids. The final product exhibits excellent properties for soil blending and land application with low odor. There are two commercially available thermal hydrolysis processes currently, Cambi and Exelys, which are described in greater detail below.

CAMBI

The Cambi THP process consists of three basic steps: solids heating in the pulper/pre-heater tank, heating, pressurization and thermal hydrolysis in the reactor, and pressure release to the flashtank. Dewatered cake of 17% solids concentration is fed from cake bins to the pulper where solids are circulated by circulation pumps and preheated with steam. Then the cake is transferred to batch reactors where steam is added to increase both temperature and pressure within the batch reactor. The batch reactor is raised to a temperature of approximately 330 degrees F and a pressure near 90 psig. After a prescribed amount of elapsed time, a pressure discharge opens and allows steam to travel to the pulper. The remaining pressure is used to transfer the solids slurry through the blow down valve to the flashtank. Excess flash steam from the flashtank is conveyed to the pulper to pre-heat the cake.

Thermally hydrolyzed sludge (THS) is continuously removed from the flashtank by digester feed pumps which convey it to a THS booster/circulation system that increases the pressure and keeps the sludge constantly moving to prevent setting. Between the flashtank and the digesters, the sludge is diluted with water from 13-15% to 8-12% percent dry solids. Without dilution, high ammonia concentrations may build-up in the digesters, high sludge temperatures may damage the digester feed pump stators and the viscosity wouldn't be conducive to digester mixing. Finally the THS is cooled by mixing with recycled digested sludge and then routed to the digester. Heat exchangers may be added upstream of each digester to cool the sludge to the proper temperature for high-rate digestion. A schematic of this process is shown in **Figure 8-4**. An example equipment installation is illustrated in **Figure 8-5**.

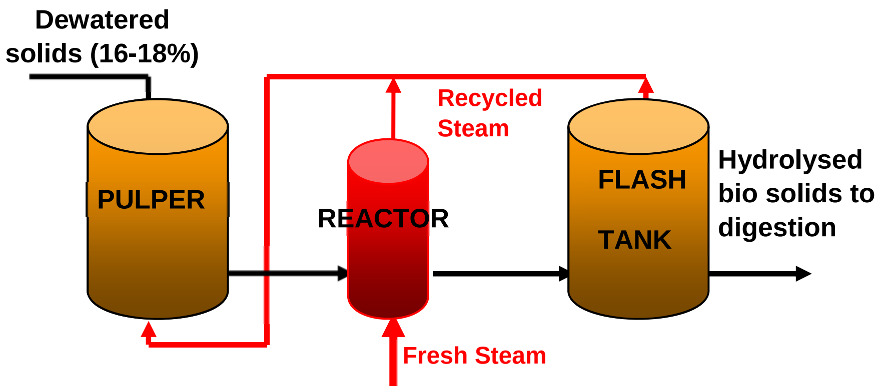

Figure 8-4
Cambi Thermal Hydrolysis Pretreatment (image courtesy CAMBI)

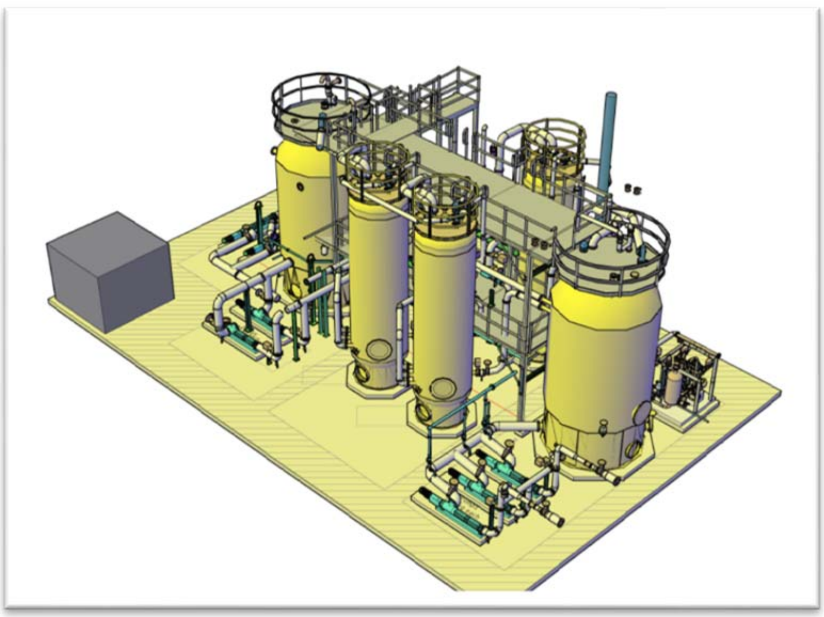

Figure 8-5
Cambi Thermal Hydrolysis System

Exelys

Exelys is another thermal hydrolysis process that is currently being developed by Kruger/Veolia. Exelys is a continuous plug flow process that treats primary and secondary sludge. Dewatered sludge from a storage silo is conveyed to the Exelys system via a progressive cavity pump. Steam is injected continuously and begins to heat the sludge up to the level at which hydrolysis can occur. The heated sludge passes through a self-cleaning static mixer before entering the reactor. The reactor operates within a temperature range of 285-330 degrees F and pressure range of 130-220 psi. After the reactor, the sludge enters a heat exchanger system where excess thermal energy can be recovered and exported from the system.

Exelys offers two configurations, the most common of which is the Exelys-LD. In the LD configuration thermal lysis (L) is followed by digestion (D), as shown in the schematic in **Figure 8-6**. The process can also be configured into a digestion - lysis – digestion configuration, called Exelys-DLD (shown in **Figure 8-7**). In the DLD configuration, sludge is digested and dewatered before entering the thermal hydrolysis reactor. Next the dewatered, hydrolyzed sludge is cooled and diluted and then sent to a second digester.

The Exelys-DLD configuration offers a number of advantages that are not available with conventional thermal hydrolysis digestion. Approximately 20-30% of the total solids entering the first digester are converted to biogas. Since digested sludge is easier to dewater than raw sludge, the Exelys system can be approximately 2/3 of the size required in an LD configuration under the same conditions.

While Exelys and Cambi both rely on thermal hydrolysis for sludge conditioning, there are a few key differences in their designs. The Exelys system does not recycle steam and therefore requires more of it than the Cambi. The Cambi process produces biosolids that meet Class A requirements of EPA Part 503, while Exelys does not. Though the Exelys process meets the Class A time and temperature requirements, there is potential for the system to short circuit since it is not a batch process. It should be noted that Veolia/Kruger also markets a batch process called Biothelys™ which is very similar to CAMBI.

8.2.4 Electrical Lysis Process

The electrical lysis process (ELP) is marketed by OpenCel and has shown promising results at full scale in a permanent installation in Mesa, Arizona. It is simpler than THP and can be implemented in phases due to its modular nature. ELP enhances WAS digestion which can improve final product stability and contribute to increased biogas production. Typically, high frequency electronic pulses are applied to the WAS stream which ruptures cell membranes and releases soluble material that can improve VSR and biogas generation. Once treated, the WAS is discharged to the digesters where VSR of the WAS portion can exceed 70 percent.

8.2.5 Dewatering

Belt Filter Press

The belt filter press (BFP) is a widely used dewatering technology with a proven track record and low operating costs. Polymer-conditioned sludge is delivered onto a porous belt through which free water drains by gravity. The biosolids are then trapped between two porous belts and passed between rollers of varying diameters that further purge water from the residuals.

Centrifuge

Centrifugation is the process in which a centrifugal force 500 to 3000 times the force of gravity is applied to a slurry to accelerate the separation of the solid and liquid fractions. Compared to BFPs, Centrifuges typically produce a 3-5% drier cake. This reduced volume of dewatered material is beneficial if drying is used downstream. Centrifuges also offer a smaller footprint, require less water, and are totally enclosed, which facilitates odor control. However, centrifuges typically have a higher capital cost, require more energy, and more polymer. Centrifuges require skilled maintenance personnel but do not need continuous operator attention.

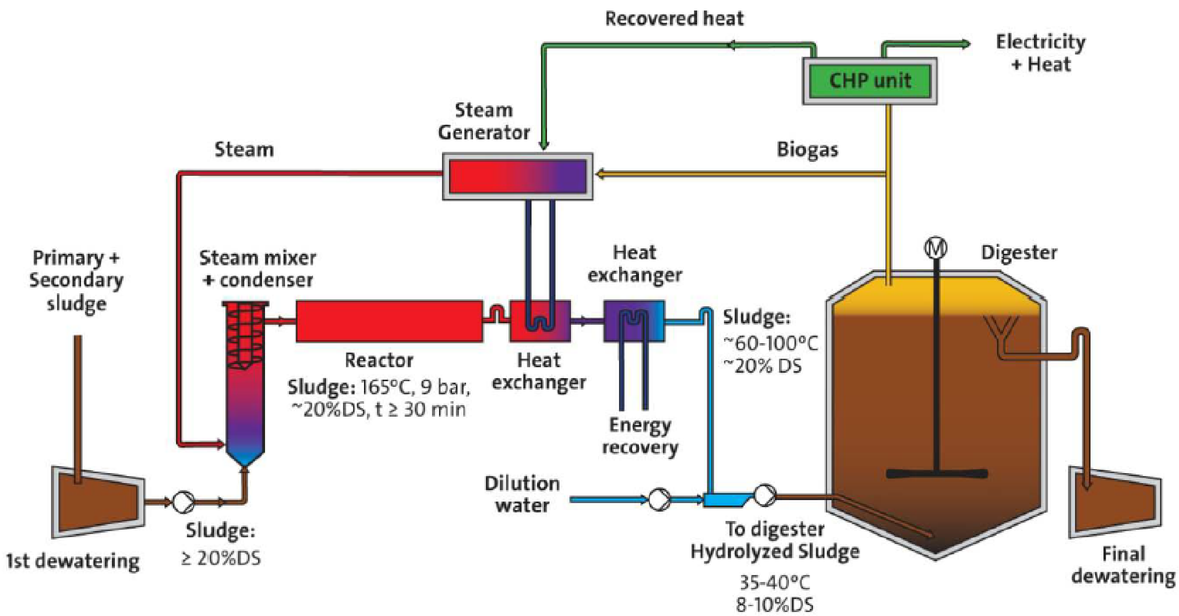

Figure 8-6
Exelys™ Thermal Hydrolysis LD Configuration (image courtesy Kruger)

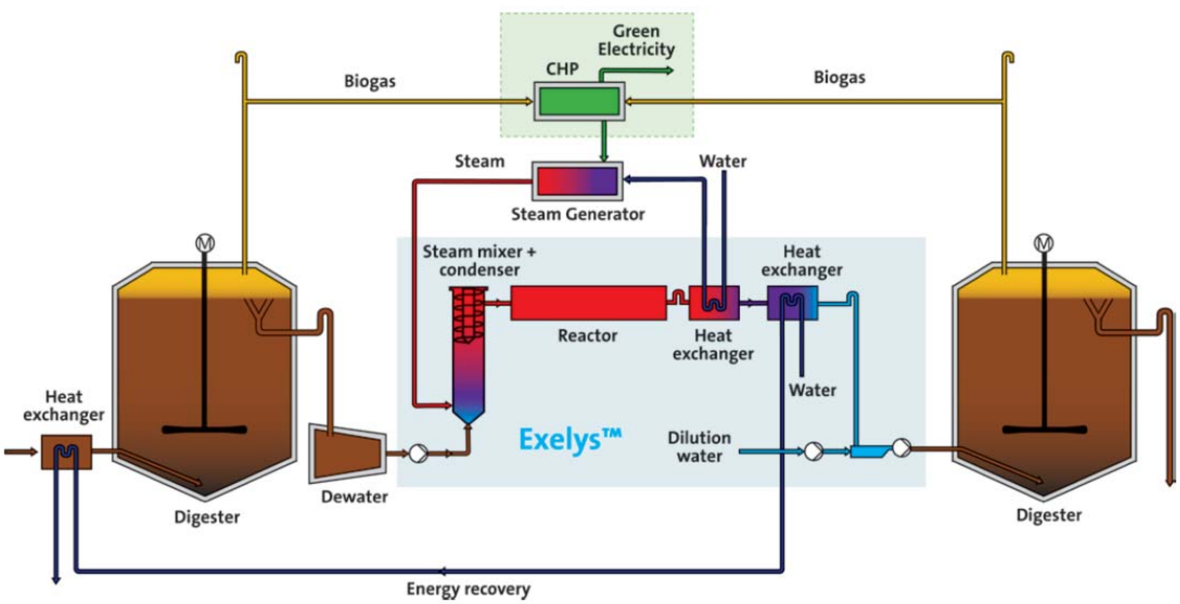

Figure 8-7
Exelys™ Thermal Hydrolysis DLD Configuration (image courtesy Kruger)

8.2.6 Drying and Thermal Processing

Solar Drying

Solar drying systems are similar to greenhouses, concentrating solar radiation inside a climate controlled building. In the case of solar dryers, however, the solar energy is harnessed to evaporate moisture from dewatered biosolids. To facilitate evaporation, the solids are turned regularly by an automated mechanical device. The air quality control system is also automated, moving air to maintain low humidity levels for drying. In some cases, the moist air removed from the system requires treatment for odors before discharge to the atmosphere. A solar drying facility is shown in **Figure 8-8.**

The solar drying system is composed of a number of drying chambers. Chambers are constructed atop concrete slabs with short side walls (3 feet), and transparent roofs. The dried biosolids typically emerge with total solids content of approximately 80%. Solar drying is not identified among the "processes for removing pathogens" (PFRPs) in US EPA 40 CFR 503, although site-specific permitting is available for facilities that demonstrate production of Class A biosolids. Solar drying may be capable of producing Class A biosolids whether or not the material has undergone thermal hydrolysis.

Drying costs and energy consumption are less than half as much in solar drying facilities when compared with traditional thermal dryers. According to information furnished by Parkson, solar dryers release one seventh as much carbon dioxide (CO_2) emissions as conventional thermal dryers. Operation is automated and maintenance requirements are low.

There are two main disadvantages of solar drying facilities. One is that the drying performance varies with climate, seasonally and regionally, making the system less predictable. The land area requirement is also dependent on climatic conditions and can be extensive.

Parkson is the leading manufacturer of solar drying systems; while Kruger is a second major supplier. The systems are substantially similar, achieving similar drying performance using fundamentally the same mechanisms. There are differences, however. For example, in the Kruger greenhouse, the biosolids are stacked in a series of separate windrows, which help to retain heat but make aeration more difficult. The Kruger system also includes a means of conveying the biosolids into the greenhouse via progressive cavity pumps, while a mechanical windrow turner disperses the biosolids. In contrast, the Parkson system requires dewatered material to be transported to each greenhouse by front-end loader. Cost estimates will be based on the Parkson system, and will assume the inclusion of a roof made from twin-wall polycarbonate and corrugated polycarbonate sheets, though glass roofs are also available.

Figure 8-8
Solar Dryers

Thermal Dryer

Thermal drying is a viable option for installation downstream of digestion and dewatering unit processes. Thermal drying catalyzes the evaporation of water contained in the dewatered product which results in a finished product with at least 90 percent solids content. This reduction in volume facilitates the transport of the dried product to distant locations where it can be reused. Since the dried product of thermal dryer meets the Class A biosolids requirements for pathogen reduction there are a range of reuse and disposal options.

There are two main categories of thermal dryers: direct dryers and indirect dryers. The main concern with indirect drying systems is that they produce a powdery, dusty product and the internal components of the dryers may be subject to excessive wear and abrasion. Drum dryer technology was selected for this analysis because drum dryers are the more proven technology. Other types of direct dryers, such as belt dryers and fluidized bed dryers, can also be considered, should a form of energy other than digester gas be used in the drying process.

Hot gas is produced in the furnace and comes in direct contact with the sludge in the dryer. The moisture in the sludge evaporates and the dried product passes through a series of separation devices that collects, screens, and classifies the solids. Material that is too large or too small is recycled and mixed with the feed sludge from the dewatering facility.

Product is passed through the system by a series of conveyors and, ultimately, to pellet storage silos. The amount of required pellet storage will vary with market conditions and the intended end user.

Thermal drying is well in line with the CMUD's interest in providing diversified disposal strategies. It is recommended to evaluate this alternative further, the details of which are included in Section 16.

8.2.7 Disposal

Land Application

Class B Biosolids may be spread on agricultural, forested, or disturbed land, as well as dedicated land disposal sites. Land application is a form of beneficial use because biosolids improve the soil's structure and water holding capacity while also providing nutrients and aeration. Pathogens and toxic organic substances are reduced in the presence of sunlight, soil microorganisms and desiccation.

Landfill

Dewatered solids can be hauled off site for disposal in a municipal solid waste landfill that has been permitted to receive wastewater solids. Landfill tipping fees and required hauling distances are expected to increase over time in the region. Although landfill disposal is not recommended as a long-term management solution, relationships with landfills need to be maintained to that this disposal option can be employed as a failsafe in the future if necessary.

Product Marketing

Distribution and marketing of water and wastewater residuals to users such as homeowners, landscape contractors, agricultural and horticultural industries is a common practice. EPA's 40 CFR Part 503 presents the requirements for Class A pathogen reduction alternatives and vector attraction reduction which are required for any product to be distributed and/or marketed to the general public. Additionally, metal concentrations must meet maximum concentrations listed in the regulations, Part 503.13.

Typically, heat dried or composted biosolids can be marketed. There are several long standing examples including Milwaukee's Milorganite (heat-dried) and Kellog Supply's Los Angeles County program (composted). In Georgia, Clayton County Water Authority produces pellets by heat drying and sells to a distributor under the trademark AGRI-PLUS 650.

It should be noted that a successful marketing implementation requires ensuring that the final product meets all EPA and state standards before it is marketed, finding high-end users who will be loyal to the program over a long term, and educating potential users on how the product is produced and how it can benefit their application.

8.2.8 Nutrient Recovery

Wastewater treatment plants concentrate phosphorus in the sludge dewatering sidestreams. Large quantities of metal salts such as alum are typically added to precipitate and remove the phosphorus. Further, the dissolved nutrients promote the formation of struvite affecting pipes, valves and pumps efficiency and operations.

To avoid chemicals purchase and sludge disposal costs, in addition to taking advantage of potential revenues from fertilizer sales, nutrient management technologies have been implemented in recent years. These processes, such as Pearl by Ostara, provide chemical precipitation in a fluidized bed reactor, removing the phosphorus load in the sludge dewatering liquid. Nutrients from the system feed streams are mixed with magnesium chloride. Sodium hydroxide is also added when needed to increase alkalinity and pH, and enhance nutrient removal. They are then fed into a fluidized bed reactor where struvite precipitates forming particles that are recovered in the form of crystalline pellets. The liquid process runs continuously. The fertilizer is removed periodically in batches and the bagged product can be potentially marketed as a commercial fertilizer.

8.3 Development of Biosolids and Residuals Management Strategies

8.3.1 Management Strategies

A preliminary screening process was conducted during Workshop 2 in December 2012 to identify the most beneficial biosolids and residuals management strategies for further evaluation. **Table 8-1** lists the key factors evaluated to characterize each strategy.

Table 8-1 Management Strategy Key Factors

Factor	Description
End Product Stability	Level of stabilization achieved to prevent further organic decay, prevent odors and reduce pathogen content. Typical processes used to achieve stabilization include digestion and thermal drying.
End Product Quantity	Volume reduction obtained through the treatment process, typically by means of digestion and dewatering.
Multiple Outlets	Ability to provide multiple disposal outlets (e.g., land application, commercial distribution and marketing, etc.).
Competition for Program Management	Processing technologies and strategies allowing for alternative solutions to current single contract disposal operations.
Energy Use and Recovery	Generation of thermal and electrical energy (typically via digestion biogas).
Sidestream Treatment and Nutrient recovery	Removal of phosphorus from dewatering sidestreams and potential distribution and marketing of recovered fertilizer.

Strategy 1 (WWTP Biosolids Baseline) and Strategy 1-B (WTP Residuals Baseline)

Strategy 1 and Strategy 1-B in **Figure 8-9** and **Figure 8-10** reflect the current management program at CMUD WWTPs and WTPs, respectively.

Reasons for Further Evaluation

Strategies 1 and 1-B represent the baseline against which other management strategies will be compared and therefore their performance for future solids production needs to be investigated.

Strategy 2 (Advanced Anaerobic Digestion)

Strategy 2, shown in **Figure 8-11**, targets a Class A end product obtained using advanced anaerobic digestion, which can be achieved using different approaches: optimizing conventional mesophilic digestion; operating at thermophilic temperatures; or separating acid and gas phases of digestion. The stabilized dewatered cake is stored and land applied.

Reasons Not to Proceed with Further Evaluation

While this strategy would produce stabilized, Class A biosolids, with reduced volume as a consequence of the reduction in volatile solids (VSR) and dewatering operations, it does not necessarily provide additional outlets by itself as a dewatered cake product is still confined to agricultural land application. Since current volatile solids reduction at the plants is already quite high, advanced digestion processes may not improve digestion performance significantly.

Strategy 3 (Pre-Treatment + Anaerobic Digestion)

Strategy 3 considers pretreatment of the sludge before digestion. Available technologies include the thermal hydrolysis process (THP), marketed by Veolia and Cambi, and the electrical lysis process (ELP), marketed by OpenCel. The THP and ELP are depicted in **Figure 8-12 and Figure 8-13**, respectively.

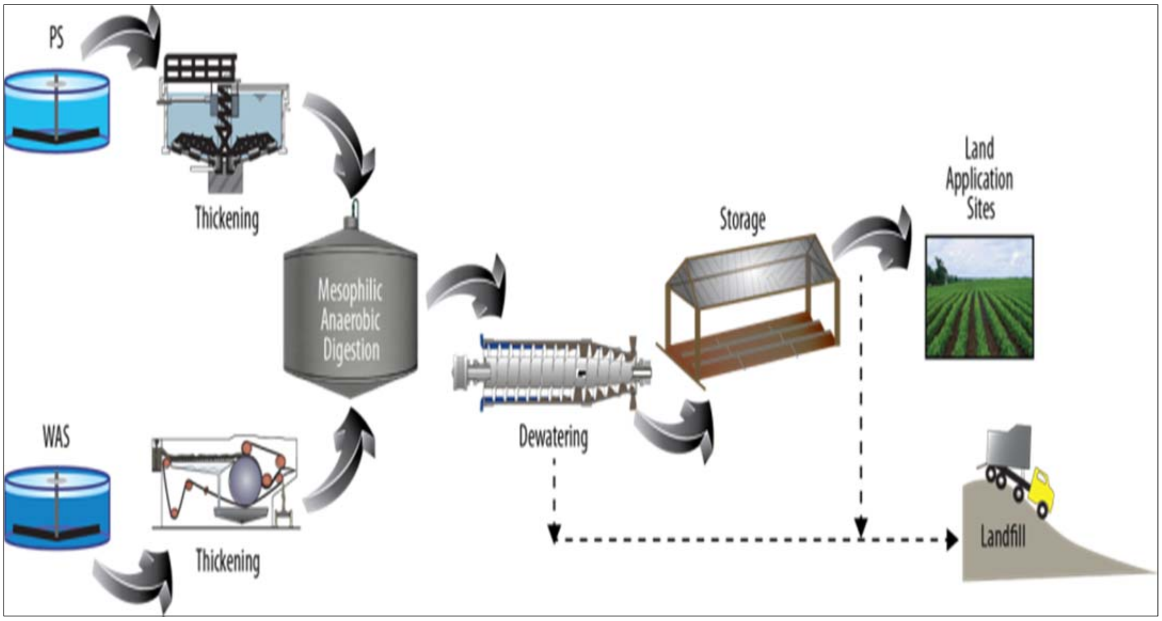

Figure 8-9
Strategy 1: WWTP Biosolids Baseline

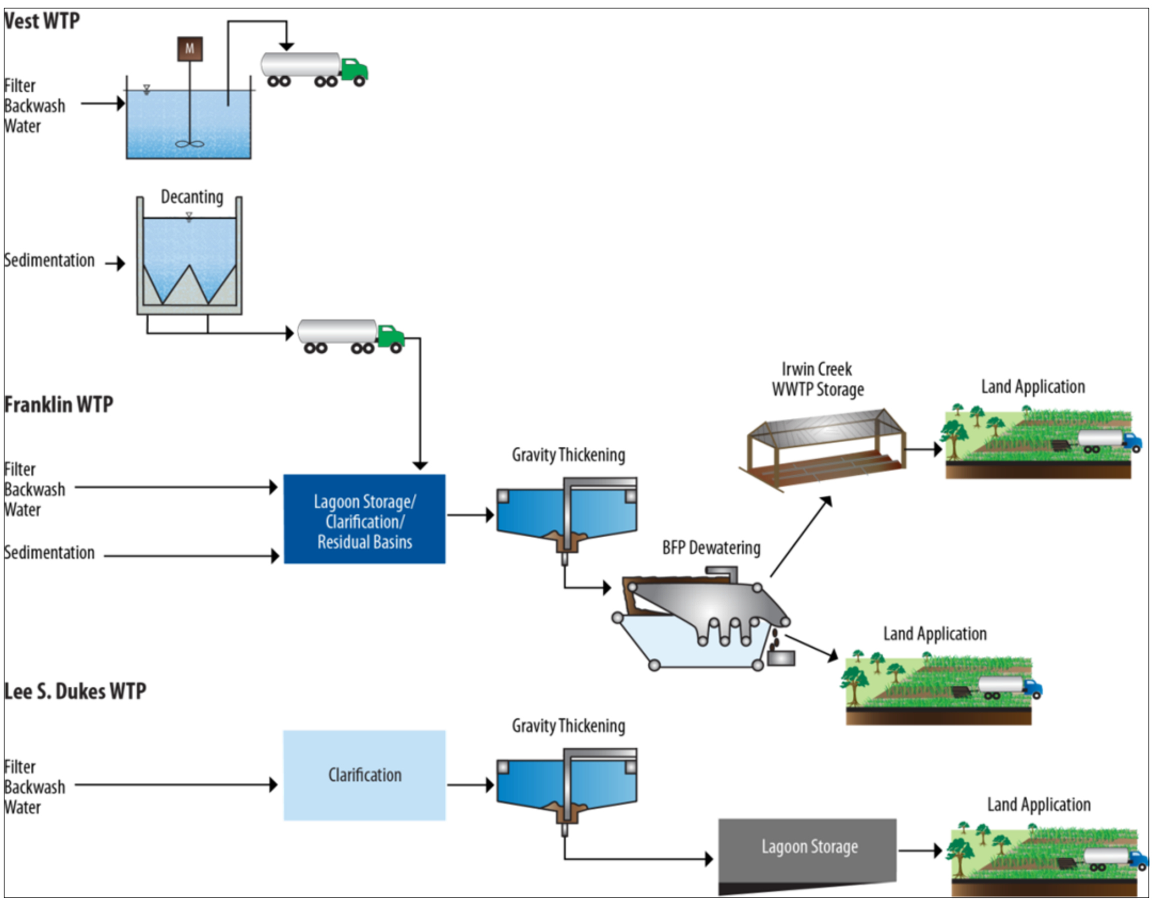

Figure 8-10
Strategy 1-B: WTP Residuals Baseline

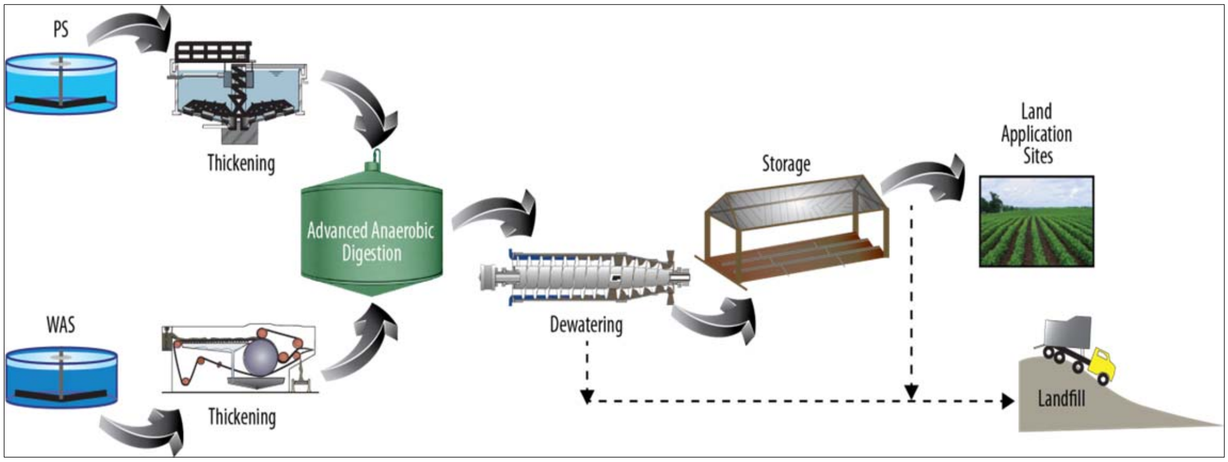

Figure 8-11
Strategy 2: Advanced Anaerobic Digestion

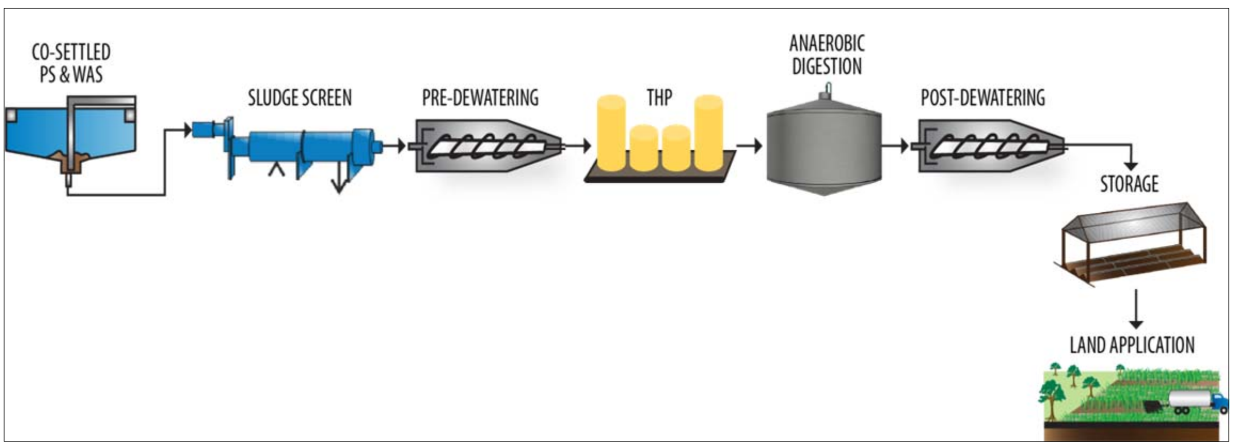

Figure 8-12
Strategy 3: THP Pretreatment and Anaerobic Digestion

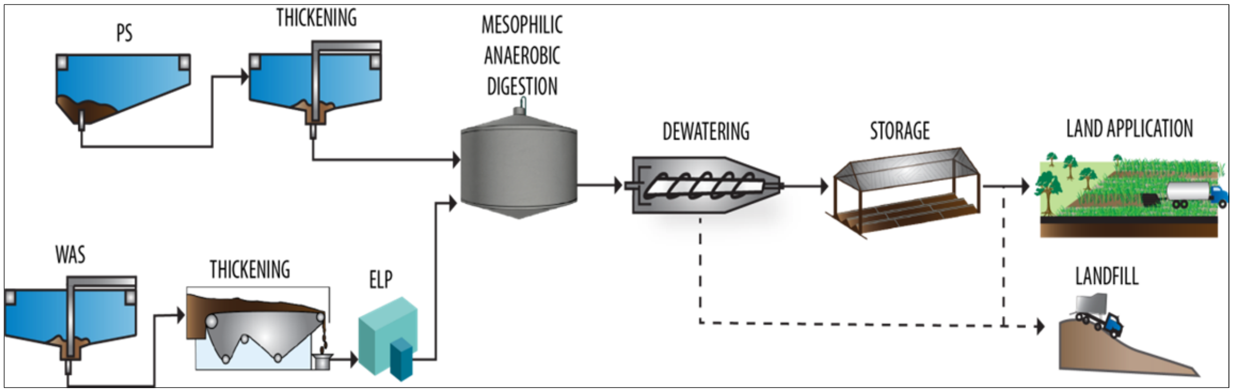

Figure 8-13
Strategy 3: ELP Pretreatment and Anaerobic Digestion

In the THP, pre-dewatered sludge is fed through enclosed reactors, in which the sludge is subjected to steam at elevated temperature (330^{o}F approx.) and pressure (90 psi approx.). Following hydrolysis, the pre-treated biosolids are fed to the anaerobic digesters at high concentration (approximately 10 percent total solids). While THP is an emerging technology, it is becoming increasingly more established (more than 20 facilities), with the largest worldwide installation currently under construction at the DC Water Blue Plains Advanced Wastewater Treatment Plant in Washington D.C. (first U.S. installation).

Reasons for Further Evaluation

Pre-treatment, either by use of the THP or ELP, offers several benefits. THP achieves Class A as pathogens are destroyed in the process and the products are practically odor free which addresses the fecal coliform and odor conditions for the McAlpine Creek WWMF biosolids. Digestion after THP yields high volatile solids destruction (up to 65 percent) and allows for increased loading to the digesters as the rheology of the sludge is drastically altered, making it easier to pump and mix. This increase in loading results in smaller digester capacity requirements, and increased biogas production. Dewatering performance improvement is also significant, resulting in a dewatered cake with solids concentration up to 30 percent solids. If Strategy 3 were to be implemented, McAlpine Creek WWMF has the potential to become a regional facility processing unstabilized liquid solids transported to this plant from the smaller facilities. Land application is the primary outlet for Strategy 3, without further processing. Biogas generated during anaerobic digestion can be used to generate steam required for the THP and to produce electric power through a CHP system.

ELP enhances WAS digestion which can improve final product stability and contribute to increased biogas production. This technology is relatively simple to implement and pilot testing is recommended at WWTPs for which this technology is considered.

Strategy 4 (Anaerobic Digestion + Thermal Drying)

Strategy 4, shown in Figure 8-14, employs anaerobic digestion and a thermal drying process to generate Class A biosolids. Thermal drying reduces mass and volume of dewatered cake by water evaporation. Numerous drying technologies are available.

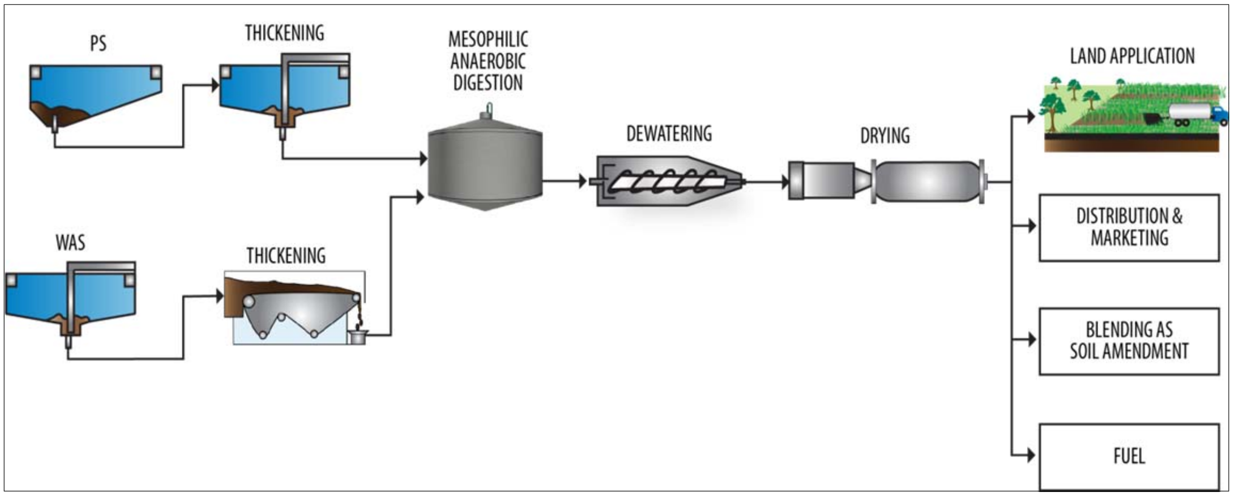

Figure 8-14
Strategy 4: Anaerobic Digestion and Thermal Drying

The selection of the dryer technology depends on the amount of water to be evaporated, desired characteristics of the dryer product, source of heat and space requirements.

Direct dryers such as drum dryers are a proven technology and typically produce a pellet with solids concentration above 90 percent solids although they may not be cost effective if the energy to operate the dryer is exclusively purchased and not generated using biogas. Hot gas is produced in the furnace and comes in direct contact with the sludge in the dryer. The moisture in the sludge evaporates and the dried product passes through a series of separation devices that collects, screens, and classifies the solids. The product is passed through the system by a series of conveyors and, ultimately, to pellet storage silos. Indirect drying systems are in general, more challenging, as they produce a powdery, dusty product and the internal components of the dryers may be subject to excessive wear and abrasion.

For the smaller WWTPs, solar drying may also be considered, as it represents an innovative technology which is gaining momentum in the U.S. While solar drying is not identified among the "processes to further remove pathogens" (PFRPs) in US EPA 40 CFR 503, site-specific permitting is typically available for facilities that demonstrate production of Class A biosolids. Solar drying systems are similar to greenhouses, in which the solar energy is harnessed to evaporate moisture from dewatered biosolids. To facilitate evaporation, the solids are turned regularly by an automated mechanical device. The air quality control system is also automated, moving air to maintain low humidity levels for drying. Solar dryers typically achieve solids concentration up to 70-75 percent solids, and their operating and maintenance cost can be less than half as direct dryers. There are two main disadvantages of solar drying facilities. One is that the drying performance varies with climate, seasonally and regionally, making the system less predictable. Typically, solar dryers have not experienced odor issue; though, depending on local characteristics, odor issues may need to be addressed. The land area requirement is also dependent on climatic conditions and can be extensive.

Reasons for Further Evaluation

Thermal drying provides a flexible management strategy. The dried product typically meets Class A biosolids requirements for pathogen reduction and achieves a significant reduction in volume, which facilitates transportation to more distant markets.

Drying further allows multiple reuse and disposal options, through distribution and marketing (D&M), land application and use of the end product as a fuel substitute, due to its high calorific value. Blending with soil as a soil amendment is also an option.

Strategy 5 (Anaerobic Digestion + Alkaline Stabilization)

Strategy 5 in **Figure 8-15** combines anaerobic digestion with alkaline stabilization, in which lime is added to the dewatered cake to raise the pH and produce Class A biosolids. A dry lime feed system, conveyance system and lime-sludge mixer are required.

Reasons Not to Proceed with Further Evaluation

Strategy 5 will not be further evaluated, due to operating issues experienced by CMUD at the Residuals Management Facility (RMF), which was designed as a Class A lime stabilization and composting facility. The original lime stabilization and composting equipment was decommissioned in approximately year 2000. Since then, the building has been used as a storage facility prior to land application.

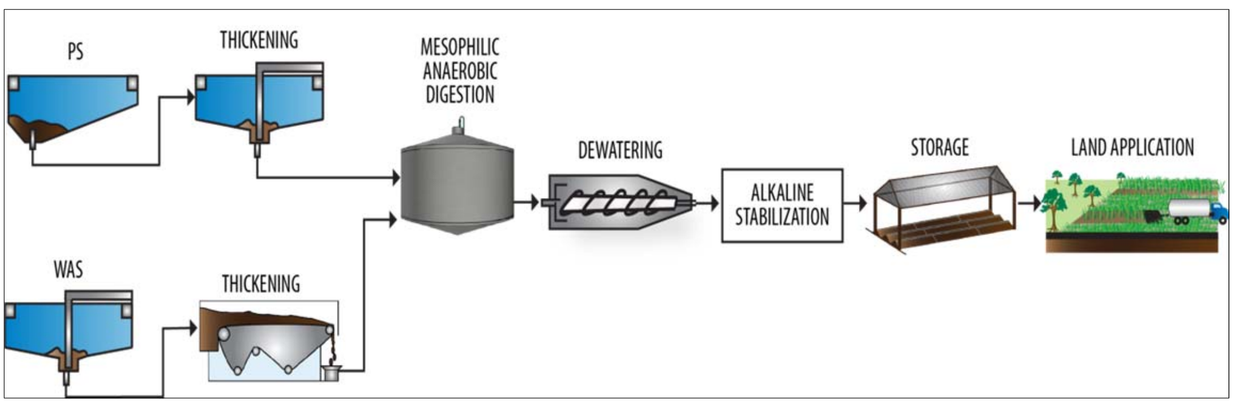

Figure 8-15
Strategy 5: Anaerobic Digestion and Alkaline Stabilization

Strategy 6 (Anaerobic Digestion + Composting)

Strategy 6 in **Figure 8-16** combines mesophilic anaerobic digestion with composting, producing Class A biosolids. While anaerobic digestion is not needed for composting, it is recommended to minimize potential odor issues.

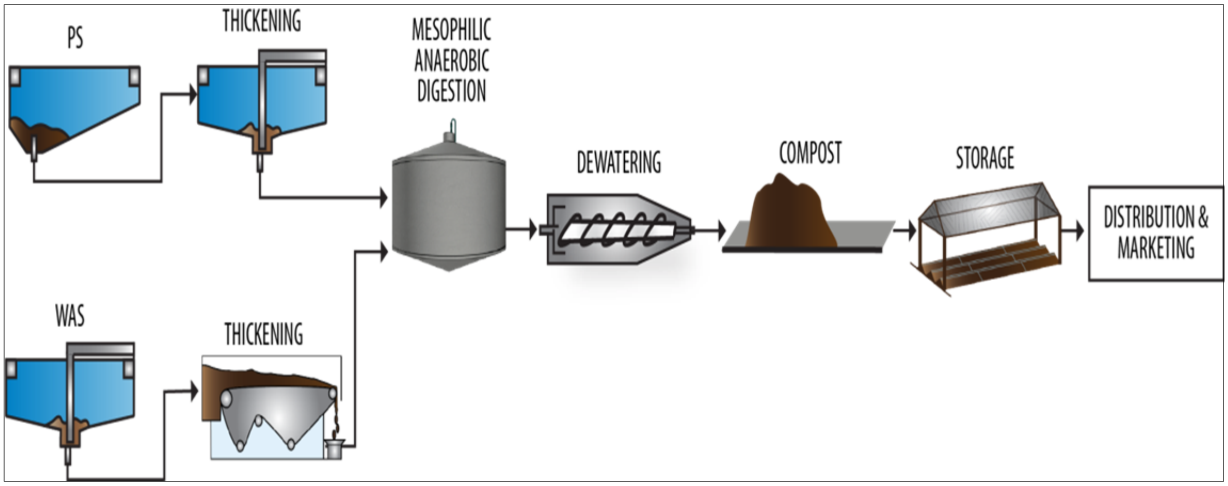

Figure 8-16
Strategy 6: Anaerobic Digestion and Composting

Reasons Not to Proceed with Further Evaluation

Strategy 6 considers composting technology in conjunction with anaerobic digestion. As a technology, composting has earned public support as a "green" technology and has the advantage of reducing the reliance on land application. At medium and large facilities the benefits of positive public perception and opportunity to achieve a Class A product are not outweighed by the following challenges associated with composting:

- Material handling requires that the wet cake be blended with a bulking agents.
- Requires significant supply and handling of bulking agents.
- In addition to space for composting process, it requires a large amount of space.
- For curing time which can last between 60 and 90 days.
- Requires large odor control systems.

Implementation of composting at any facility is not recommended due to the reasons listed above.

Strategy 7 (Anaerobic Digestion + Incineration)

Strategy 7, exhibited in **Figure 8-17**, evaluates incineration. The only product of incineration is ash, which can be landfilled. If incineration is to be considered further, anaerobic digestion process should be eliminated as the fuel value of the sludge can be better preserved without digestion.

Reasons Not to Proceed with Further Evaluation

The implementation of new incinerators offers several challenges, such as adverse public perception, extreme emission control requirements, and extensive permitting process.

While third party incineration could be of interest if a private firm is willing to build a plant that can utilize CMUD biosolids, this may not be feasible due to energy prices and public awareness, and would increase risk associated to a single disposal outlet. Further, the capital investment is significant and more so now with the new MACT Rule and Title V air permit requirements.

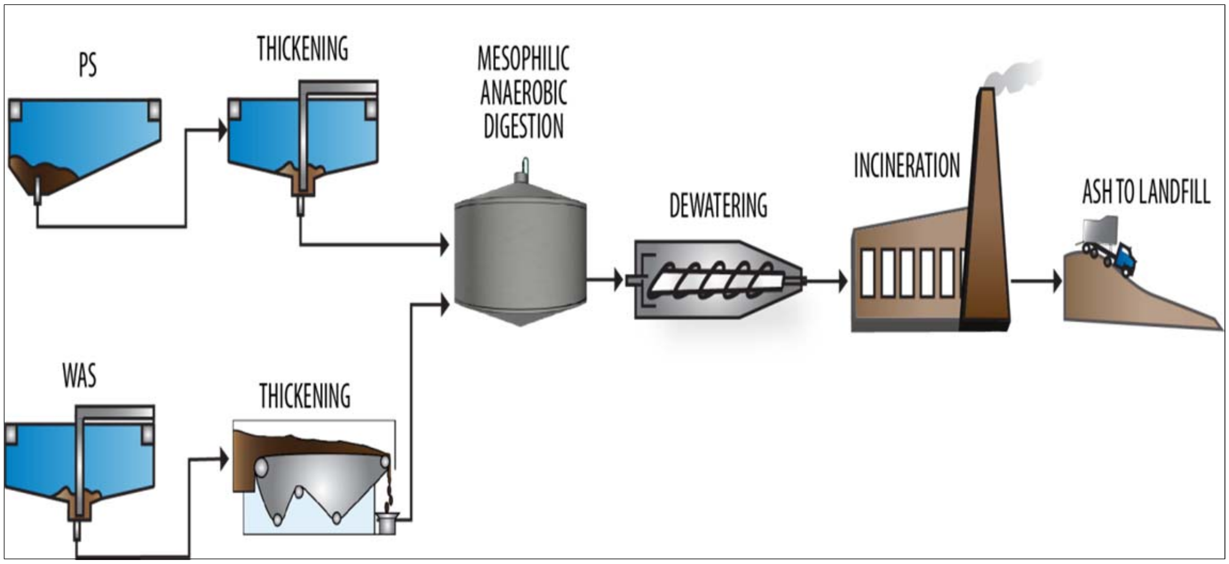

Figure 8-17
Strategy 7: Anaerobic Digestion and Incineration

Strategy 8 (Anaerobic Digestion + Drying + Gasification/Pyrolysis)

Strategy 8, depicted in **Figure 8-18**, evaluates anaerobic digestion coupled with thermal drying followed by either gasification or pyrolysis. Gasification uses a small amount of oxygen whereas pyrolysis uses none. Both generate an ash product which can be landfilled, and utilize the heat generated from the drying process.

Reasons Not to Proceed with Further Evaluation

Pyrolysis and gasification are complex processes requiring significant capital investment and with only a limited number of installations. The only gasification facility in the U.S. was installed at the Sanford WWTP in Florida, but has experienced various operating issues. Further development of these technologies is needed to make this strategy viable.

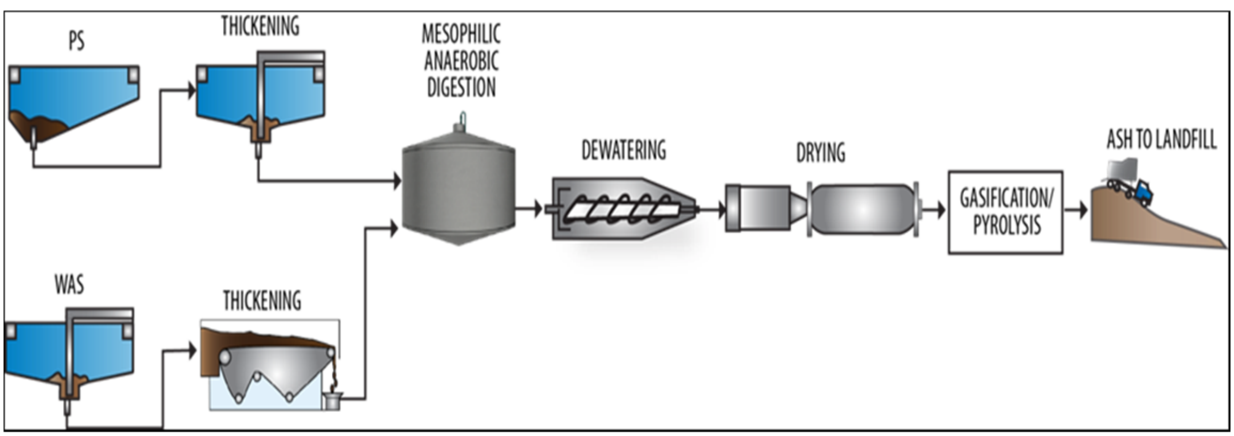

Figure 8-18
Strategy 8: Anaerobic Digestion, Drying, and Gasification/Pyrolysis

Strategy 9 (Anaerobic Digestion + Drying + Vitrification)

Strategy 9, shown in **Figure 8-19**, utilizes vitrification following anaerobic digestion and thermal drying. Vitrification applies extreme heat and melts the sludge in a cyclone furnace which produces a fine, glass like product that can be used in products for construction.

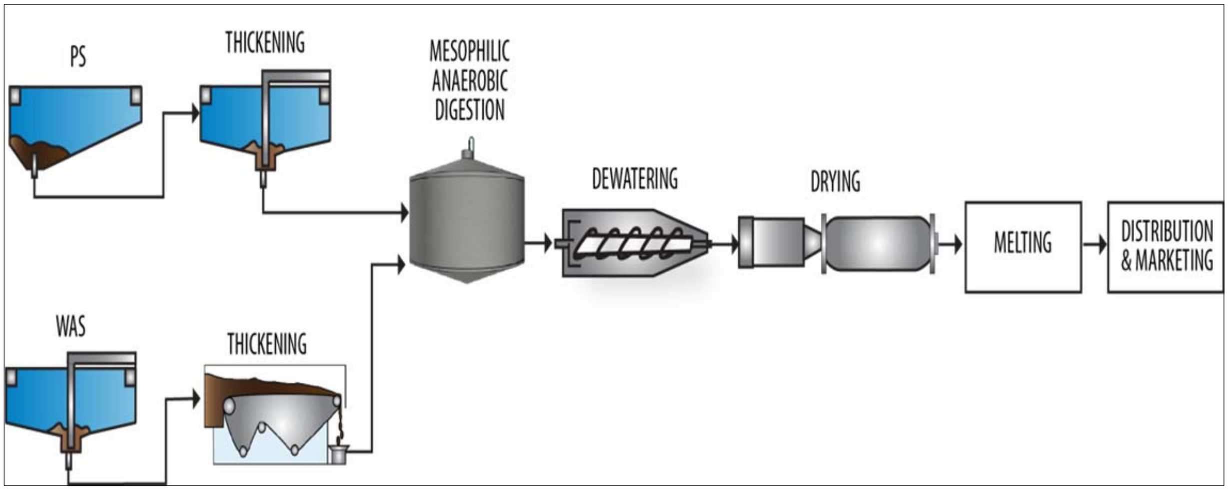

Figure 8-19
Strategy 9: Anaerobic Digestion, Drying, and Vitrification

Reasons Not to Proceed with Further Evaluation

Similarly to pyrolysis and gasification, this is an innovative technology. The North Shore Sanitary District near Chicago has implemented vitrification at the Zion plant. However, since this facility became operational, it has experienced problems that have prevented it from achieving full production and has been shut down.

Strategy 10 (Anaerobic Digestion + Third Party Contracting)

Strategy 10, shown in **Figure 8-20**, evaluates the possibility for CMUD to enter into an agreement with a third-party contractor treating and disposing of the dewatered solids.

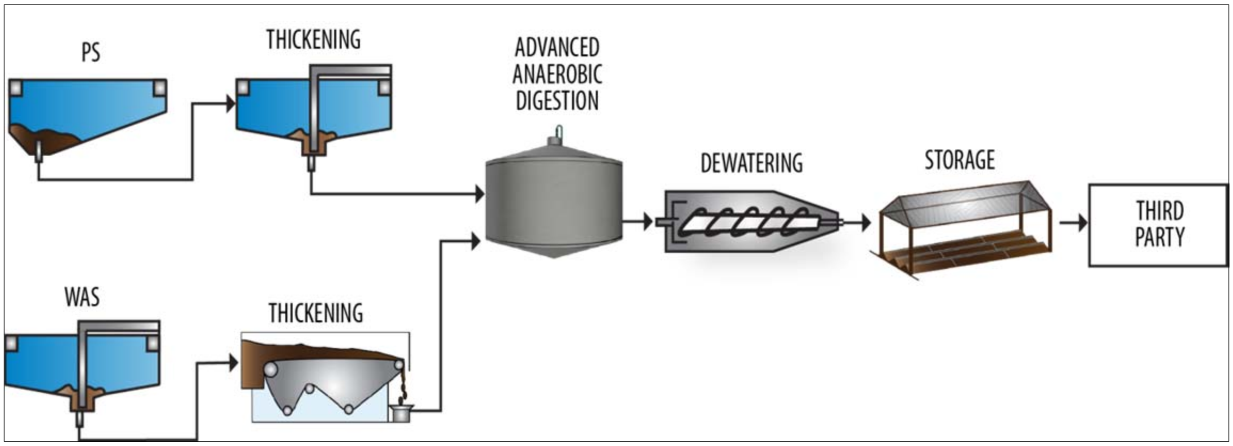

Figure 8-20
Strategy 10: Anaerobic Digestion and Third Party Contracting

Reasons for Further Evaluation

A qualitative evaluation of this strategy will be conducted as it may be of interest in the future, should an opportunity arise to partner with a third-party contractor. However the analysis will be limited to assessing the risk and identify the criteria required for consideration of a third party contractor.

Strategy 11 (WTP Residuals Dewatering and Pumping)

Strategy 11, shown in **Figure 8-21**, includes pumping of solids from Vest WTP to Franklin WTP, addition of a storage facility at Franklin WTP, and possibly a dewatering facility at Lee S. Dukes WTP.

Reasons for Further Evaluation

This strategy aims at reducing hauling costs for transporting liquid sludge from Vest WTP to Franklin WTP. The addition of a storage facility at Franklin WTP negates the need to haul Franklin WTP residuals to Irwin Creek WWTP prior to land application. Finally, providing dewatering equipment at Lee S. Dukes WTP would limit the frequency at which solids are pumped out from the existing lagoon, increasing its effective storage capacity.

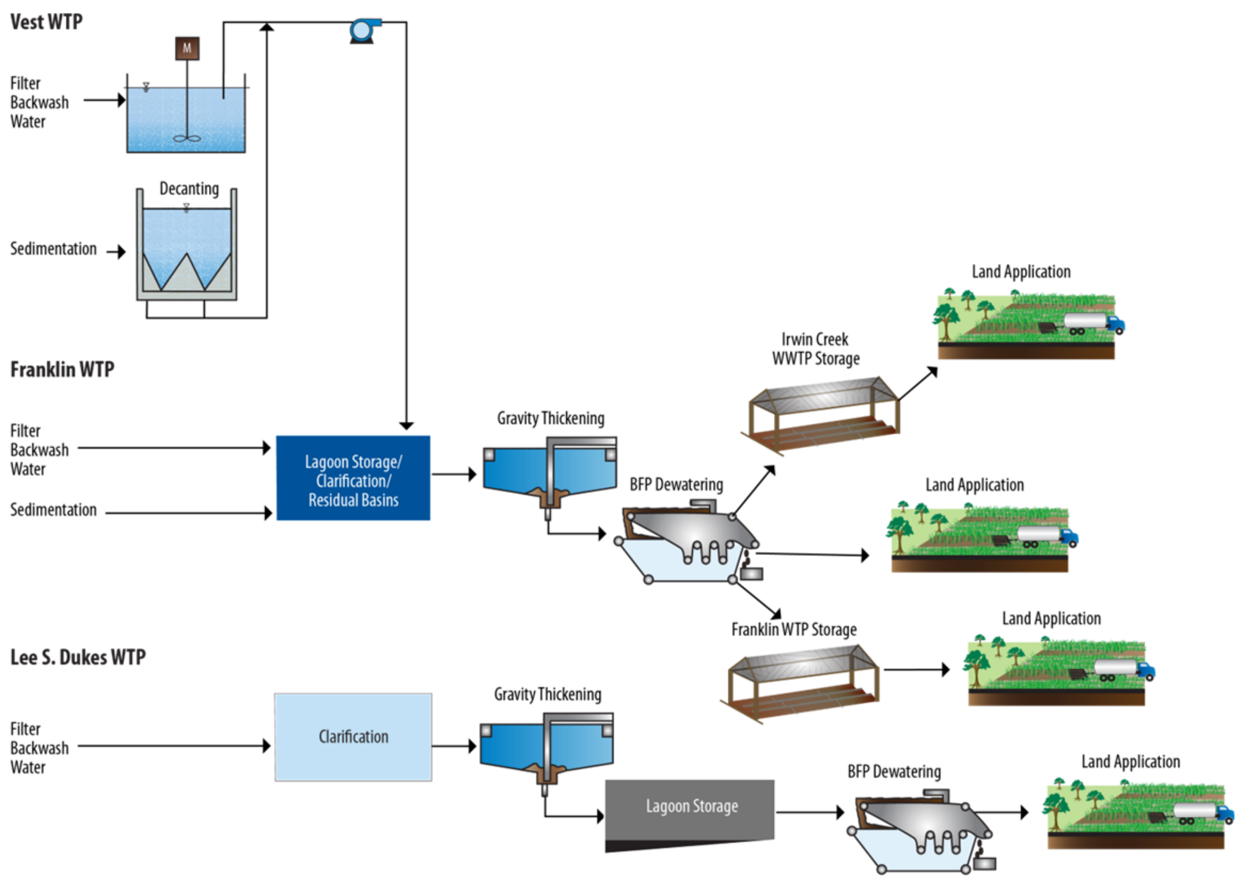

Figure 8-21
Strategy 11: WTP Residuals Dewatering and Pumping

8.4 Development of Alternatives

8.4.1 Initial Screening of Alternatives

For each selected management strategy, Tables 8-2 through 8-8 present a matrix of alternatives for further screening. These alternatives define different ways to implement each strategy at CMUD facilities.

For example, Alternative 3-3 considers pre-treatment coupled with anaerobic digestion at the McAlpine Creek WWMF. The McAlpine Creek WWMF THP pre-treatment system would also process liquid, unstabilized solids transported from Mallard Creek WRF and McDowell Creek WRF.

The screening of alternatives is conducted based on their applicability to the individual facilities. For example, Alternative 3-1 evaluates pre-treatment using THP technology at all WWTPs (except Sugar Creek WWTP) upstream of anaerobic digestion. This option is not realistic because THP does not offer high returns on investment at smaller facilities, like Mallard Water Reclamation Facility (WRF) and McDowell Creek WRF. It is a fairly complex technology and better suited for implementation in larger facilities like McAlpine Creek WWMF. Therefore, Alternative 3-1 is not considered for further evaluation.

Strategy 1 and Strategy 1-B Alternatives

As discussed, Strategy 1 reflects current operations at the WWTPs and represent the baseline for other strategies. Alternative 1-1 in **Table 8-2** consists of existing anaerobic digestion at all WWTPs followed by land application of Class B dewatered cake.

Similarly, Alternative 1-B in **Table 8-3** matches existing operations at the WTPs. Residuals produced at Franklin WTP are dewatered on site together with the residuals transported from the Vest WTP, and land applied. The solids from the lagoon at Lee S. Dukes WTP are land applied without further treatment.

Selection of Alternatives

Both Alternative 1 and Alternative 1-B will be evaluated to analyze baseline performance for projected solids production in the future and for comparison to other alternatives.

Strategy 3 (Pre-Treatment + Anaerobic Digestion) Alternatives

All alternatives for Strategy 3, with the exception of Alternative 3-7, incorporate THP for pre-treatment at McAlpine Creek WWMF, since THP is best suited technology for mid to large facilities. Following pre-treatment, the Class A digested biosolids are dewatered and land applied. Alternative 3-7 is instead based on the application of an ELP at all facilities, including McAlpine Creek WWMF. These Alternatives are depicted in **Table 8-4**.

Selection of Alternatives

Alternative 3-4, 3-6, 3-7, and 3-8 will be further evaluated. Alternative 3-4 assumes that liquid solids from Irwin Creek WWTP are transported to McAlpine Creek WWMF, where they are fed to the THP pre-treatment process prior to anaerobic digestion, dewatering and Class A land application. Alternative 3-6 consists of THP at McAlpine Creek WWMF, pumping of undigested sludge from Irwin to McAlpine Creek WWMF, and ELP at the other facilities.

With this alternative, capital costs associated with digester and dewatering equipment improvements and facility expansion at Irwin Creek WWTP can be avoided. This alternative would require an increase in sludge receiving and thickening capacities at McAlpine Creek WWMF. Alternative 3-8 considers THP pretreatment at McAlpine Creek WWMF and ELP at all other facilities.

The other alternatives are excluded from further evaluation because THP is primarily targeted for medium to large facilities and would be cost prohibitive for the smaller CMUD plants.

Strategy 4 (Anaerobic Digestion + Thermal Drying) Alternatives

Strategy 4 discusses thermal drying independently of pretreatment options. Strategy 3+4 will consider drying in conjunction with pretreatment. **Table 8-5** exhibits the various Alternatives of Strategy 4 that have been considered thus far.

Table 8-2 Strategy 1 Current WWTP Biosolids Management Strategies (Baseline)

WWTP	McAlpine	Irwin	Mallard	McDowell
Alternative 1-1	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion

Table 8-3-Strategy 1-B Current WTP Residuals Management Strategies (Baseline)

WTP	Franklin	Vest	Lee S. Dukes
Alternative 1B-1	Dewatering of residuals produced at Franklin and Vest	Liquid residuals transported to Franklin	Land application of residuals withdrawn from lagoon

Table 8-4-Strategy 3 Pretreatment and Anaerobic Digestion Alternatives

WWTP	McAlpine	Irwin	Mallard	McDowell
Alternative 3-1	Add THP upstream of Anaerobic Digestion	Add THP upstream of Anaerobic Digestion	Add THP upstream of Anaerobic Digestion	Add THP upstream of Anaerobic Digestion
Alternative 3-2	Add THP upstream of Anaerobic Digestion	Add THP upstream of Anaerobic Digestion	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion
Alternative 3-3	Add THP upstream of Anaerobic Digestion	Add THP upstream of Anaerobic Digestion	Transport undigested, dewatered cake to McAlpine for treatment	Transport undigested, dewatered cake to McAlpine for treatment
Alternative 3-4	Add THP upstream of Anaerobic Digestion	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion
Alternative 3-5	Add THP upstream of Anaerobic Digestion	Transport undigested, dewatered cake to McAlpine for treatment	Transport undigested, dewatered cake to McAlpine for treatment	Transport undigested, dewatered cake to McAlpine for treatment
Alternative 3-6	Add THP upstream of Anaerobic Digestion	Pump liquid sludge to McAlpine for treatment	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion
Alternative 3-7	Add ELP upstream of Anaerobic Digestion	Add ELP upstream of Anaerobic Digestion	Add ELP upstream of Anaerobic Digestion	Add ELP upstream of Anaerobic Digestion
Alternative 3-8	Add THP upstream of Anaerobic Digestion	Add ELP upstream of Anaerobic Digestion	Add ELP upstream of Anaerobic Digestion	Add ELP upstream of Anaerobic Digestion

Table 8-5-Strategy 4 Anaerobic Digestion and Drying Alternatives

WWTP	McAlpine	Irwin	Mallard	McDowell
Alternative 4-1	Add thermal dryer downstream of dewatering	Add thermal dryer downstream of dewatering	Add thermal dryer downstream of dewatering	Add thermal dryer downstream of dewatering
Alternative 4-2	Add thermal dryer downstream of dewatering	Add thermal dryer downstream of dewatering	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion
Alternative 4-3	Add thermal dryer downstream of dewatering	Add thermal dryer downstream of dewatering	Transport dewatered cake to McAlpine for drying	Transport dewatered cake to McAlpine for drying
Alternative 4-4	Add thermal dryer downstream of dewatering	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion
Alternative 4-5	Add thermal dryer downstream of dewatering	Transport dewatered cake to McAlpine for drying	Transport dewatered cake to McAlpine for drying	Transport dewatered cake to McAlpine for drying
Alternative 4-6	Add thermal dryer downstream of dewatering	Maintain Anaerobic Digestion	Transport dewatered cake to McAlpine for drying	Transport dewatered cake to McAlpine for drying
Alternative 4-7	Add solar dryer downstream of dewatering	Add solar dryer downstream of dewatering	Add solar dryer downstream of dewatering	Add solar dryer downstream of dewatering
Alternative 4-8	Add thermal dryer downstream of dewatering	Add solar dryer downstream of dewatering	Add solar dryer downstream of dewatering	Add solar dryer downstream of dewatering
Alternative 4-9	Add thermal dryer downstream of dewatering	Add solar dryer downstream of dewatering	Transport dewatered cake to McAlpine for drying	Transport dewatered cake to McAlpine for drying
Alternative 4-10	Add thermal dryer downstream of dewatering	Transport dewatered cake to McAlpine for drying	Add solar dryer downstream of dewatering	Add solar dryer downstream of dewatering
Alternative 4-11	Add thermal dryer downstream of dewatering	Add solar dryer downstream of dewatering	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion
Alternative 4-12	Add thermal dryer downstream of dewatering	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion	Add solar dryer downstream of dewatering

Alternative 4-1 evaluates installing thermal dryers at all plants. This option is unrealistic for the following reasons:

- Drying of solids at all plants does not lead to outlet-diversification which is an important criterion for CMUD's biosolids management planning. The strategy should instead involve drying a reasonable percentage of the solids initially.
- Since McAlpine WWMF constitutes about 60% of the solids production, adding a dryer at McAlpine WWMF provides outlet-diversification and is more realistic in terms of cost and maintenance requirements.

- Dedicated specifically trained personnel are required if the dryers are to be operated by plant staff. Third-party contractors may be hired to operate such dryers.

Alternative 4-2 examines the installation of thermal dryers at McAlpine Creek WWMF and Irwin Creek WWTP facilities. This option will not be further evaluated because independent operation of dryers at Irwin WWTP is not recommended. Alternatives 4-3, 4-5 and 4-6 consider the possibility of hauling sludge from Mallard Creek WRF and McDowell Creek WRF to McAlpine Creek WWMF for drying. Implementation of this alternative would incur unnecessary hauling costs and risks and will be excluded from further consideration.

Alternative 4-4 will be further evaluated as it offers thermal drying at McAlpine Creek WWMF only. The disadvantages of operational complexity and increased capital costs associated with this option are outweighed by the following advantages:

- Produces Class A product.
- Increases outlet diversification.
- Affects minimal disturbance to existing operations at other facilities.
- Achieve economies of scale by implementing thermal drying at McAlpine Creek WWMF, since it is a large facility.

Alternative 4-7 evaluates the implementation of solar drying at all wastewater facilities while Alternative 4-8 evaluates thermal drying at McAlpine Creek WWMF and solar drying at all other facilities.

Since it takes advantage of solar energy, solar drying realizes O&M savings when compared to the cost of other drying technologies that have high energy requirements. Alternatives 4-7 and 4-8 were excluded from further evaluation because solar dryers have substantial space requirements that cannot be met at McAlpine Creek WWMF, Irwin Creek WWTP, and Mallard Creek WRF.

Alternatives 4-9, 4-10, and 4-11 evaluate implementation of thermal drying at McAlpine Creek WWMF, and various combinations of solar drying and hauling of dewatered cake from Mallard, McDowell, and Irwin Creek WWTPs to McAlpine Creek WWMF. These Alternatives were eliminated from further consideration due to insufficient land area to accommodate solar drying and unrealistic sludge transfer requirements.

Alternative 4-12 considers thermal drying and McAlpine WWMF and solar drying at McDowell Creek WRF, without any sludge transfer between plants. This alternative will be further evaluated for the following reasons:

- Achieve Class A product and diversify outlets at McAlpine Creek WWMF and McDowell Creek WRF.
- Take advantage of the available space at McDowell Creek WRF to meet the significant land requirements of solar drying.
- Affect minimal impact to current operations at Irwin and Mallard Creek WWTPs.
-

Strategy 3+4 (Pretreatment and Drying)

Strategy 3+4, summarized in **Table 8-6**, combines the advantages of management strategies 3 and 4 by providing adaptability for staged implementation of the technologies of each. Alternative 3+4-1 considers both THP and thermal drying at McAlpine WWMF. This approach could be phased with THP installed first. No changes at the other plants are implemented.

Table 8-6-Strategy 3+4 Pretreatment, Anaerobic Digestion, and Drying Alternatives

WWTP	McAlpine	Irwin	Mallard	McDowell
Alternative 3+4-1	Add THP upstream of AD and thermal drying downstream of Anaerobic Digestion	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion
Alternative 3+4-2	Add THP upstream of AD and thermal drying downstream of Anaerobic Digestion	Pump liquid sludge to McAlpine for treatment	Maintain Anaerobic Digestion	Maintain Anaerobic Digestion
Alternative 3+4-3	Add THP upstream of AD and thermal drying downstream of Anaerobic Digestion	Add ELP upstream of Anaerobic Digestion	Add ELP upstream of Anaerobic Digestion	Add ELP upstream of Anaerobic Digestion

Alt 3+4-2 considers piping raw WAS and primary sludge to McAlpine Creek WWMF from Irwin Creek WWTP. The combined liquid waste stream would undergo pretreatment with the THP followed by anaerobic digestion (AD) and thermal drying. Alternative 3+4-3 considers THP, AD and thermal drying at McAlpine Creek WWMF in conjunction with ELP and AD at all other wastewater facilities. These three alternatives are selected for further evaluation based on the justifications presented in **Section 15**. An additional alternative will be considered that evaluates the option of solar drying at McDowell Creek WRF in additional with some of the other implementations associated with Strategy 3+4.

Strategy 10 (Anaerobic Digestion + Third Party Contracting) Alternatives

Management strategy 10 considers the continuation of anaerobic digestion at all facilities in conjunction with the implementation approach of third-party contracting.

The example of the Rialto Regional Biosolids Processing Facility, which was shut down recently, shows that relying exclusively on a third party for sludge processing and disposal is considerably risky because it leaves a utility at the mercy of the third-party's ability to run their operations reliably. If the third party contractor stops accepting the dewatered sludge, there are no alternative outlets available. Short- and long-term implementation strategies to involve a third-party contractor will be further evaluated.

Strategy 11 (WTP Residuals Dewatering and Pumping) Alternatives

Strategy 11 involves water treatment plant residuals management options. Alternative 11-1 evaluates residuals dewatering technologies at Lee S. Dukes WTP and Franklin WTP. Congruent with this alternative, Franklin WTP receives residuals pumped from Vest WTP. Alternative 11-2 considers discharge of residuals to the existing sewer system. Under this alternative, residuals from Vest and Franklin WTPs would be discharged to sewer and receive further treatment/handling at Irwin Creek WWTP. Similarly, residuals from Lee S. Dukes WTP would be discharged to the sewer for further treatment at McDowell WRF. Both alternatives will be further evaluated by means of considering the following:

- Impacts on the conveyance system.
- Potential changes to the character of the wastewater.
- Potential industrial allocation impacts.
- Hydraulic issues.
- Impacts on solids handling and digester capacities.

Table 8-7-Strategy 10 Third Party Contracting Alternatives

WWTP	McAlpine	Irwin	Mallard	McDowell
Alternative 10	Third Party Contractor disposes of dewatered cake	Third Party Contractor disposes of dewatered cake	Third Party Contractor disposes of dewatered cake	Third Party Contractor disposes of dewatered cake

Table 8-8- Strategy 11 WTP Residuals Dewatering and Pumping Alternatives

WTP	Franklin	Vest	Lee S. Dukes
Alternative 11-1	Dewater On-Site and Provide Dewatered Solids Storage	Liquid residuals pumped to Franklin	Dewater On-Site
Alternative 11-2	Residual Discharge to Sewer; No Treatment On-Site	Residual Discharge to Sewer; No Treatment On-Site	Residual Discharge to Sewer; No Treatment On-Site

Section 9

Alternatives Evaluation Criteria

This section presents the methodology that was used to evaluate biosolids and residuals management alternatives, including proposed cost and non-cost criteria.

The biosolids and residuals alternatives were subjected to two different evaluations, one based upon cost and the other based upon qualitative criteria developed during Workshop 2. This section establishes the framework for this analysis, defining general cost assumptions and the qualitative criteria used for the evaluation.

9.1 Design Basis and Equipment Sizing Criteria

9.1.1 Mass Balance

A mass balance was developed for each management alternative to determine solids and hydraulic loadings at each step in the process train. The equipment was sized based on the results of the mass balance for projected maximum month solids production in year 2035, with the exception of the solar dryers and anaerobic digesters. Solar dryers were sized based on average day solids production and the capacity of the anaerobic digesters was based on 14 day peak conditions.

9.1.2 Phased Implementation

The equipment requirements (e.g., number of units, capacity and operating time) for future conditions were evaluated. When feasible and cost effective, phased implementation was considered for the selected biosolids and residuals alternatives. Phased implementation would allow the timing of capital expenditures to be adjusted based on changes in sludge loading rates, economic conditions, or the availability of funds.

9.1.3 Equipment Operating Time and Redundancy

In general, mechanical equipment was sized based on a 24-hours per day, 7 days per week under maximum month conditions at ultimate capacity (year 2035). Therefore, under average daily conditions, the operating time would be less. This approach was deemed acceptable to avoid oversizing equipment based on conditions distant in time. Provisions were made for a standby unit, which could be brought into service to reduce the daily operating time.

Thermal dryers will be generally operated 24 hours a day to maximize efficiency. 24-hour operation over a 5-day work week was assumed for this equipment under annual average conditions, and continuous operation was assumed under max month conditions. No redundancy was provided for the thermal dryer and thermal hydrolysis process, since the cost of providing a redundant train is substantial, and biosolids could be diverted to other outlets in the event of a shutdown.

9.2 Basis of Cost Analysis

The cost analysis of each alternative includes the development of a total life cycle cost analysis, based on conceptual construction and annual O&M costs. The cost figures developed not only facilitate the comparison between alternatives but also indicate the order-of-magnitude of the cost for implementing each biosolids and residuals management alternative.

The opinions of probable cost are based on the conceptual design of each alternative to determine the equipment, land area, process building, storage, utility, maintenance and staffing requirements. The conceptual construction costs were prepared using quotations from qualified equipment vendors, recent bid tabs, and recent cost estimates prepared for similar projects. Construction of electrical structures and instrumentation costs were calculated as percent of the equipment cost.

9.2.1 Conceptual Capital Cost Development

The conceptual opinion of probable construction cost was developed to compare alternatives relative to one another. In addition to direct construction costs (equipment, labor, and materials), capital cost estimates include a number of indirect costs, as illustrated in **Table 9-1.** All capital costs in this report are reported in January 2013 dollars.

Table 9-1 Summary of Indirect Construction Cost Assumptions

Item	Percentage	Basis	
Subtotal Direct Construction Costs (Equipment, Labor, Materials)			**TOTAL A**
Sales Tax	6.75%	Equipment Only	↓
Building Permits	0.25%	of A	
Builders Risk and Liability Insurance	2%	of C	
Performance and Payment Bonds	1.50%	of C	
Subtotal Direct Construction Cost and Fees			**TOTAL B**
Contractor General Conditions	8%	of B	↓
Contactor General Overhead	5%	of B	
Contractor Profit	5%	of B	
Subtotal Direct Construction Cost + Contractor OH&P			**TOTAL C**
Construction Contingency	25%	of C	↓
Subtotal Direct Construction Cost + Contingency			**TOTAL D**
Design Engineering Services	7.5%	of D	↓
Engineering Services During Construction	7.5%	of D	
Owners Administration, Legal and Bonding	3%	of D	
Total Project Cost			**TOTAL E**

The intended use of this opinion of probable costs is to compare alternatives relative to one another. The final cost of any project described in this report will depend on project complexity, actual labor and material costs, competitive market conditions, actual site conditions, final scope of work, implementation schedule, and engineering. The cost of buffer zones to reduce visual, odor, traffic and noise impacts was not included in this analysis.

Total costs includes markups for taxes, permits, bonds, insurance, contractor's general conditions, overhead and profit, engineering services during design and construction, administrative costs, and contingency.

9.2.2 Operations and Maintenance Costs Development

In addition to capital costs, total project life-cycle costs are influenced by the ongoing O&M costs associated with the selected treatment technologies and the sequence in which these processes are deployed in the overall management of residuals from the system. O&M unit costs ($/dry ton) for each residuals unit process were developed based on the mass of material entering the specific unit process. These costs were estimated using the assumptions for power, labor, chemicals and other cost components shown in **Table 9-2**. These unit costs were provided by CMUD based on current operations.

Table 9-2 Unit O&M Cost Assumptions

O&M Parameter	Unit Cost
Labor and Utilities	
Labor cost (including fringe benefits)	$24.65 per hour
Electricity cost	$0.056 per KWH
Natural gas cost	$8.00 per MMBTU
Polymer cost	McAlpine: $1.59 per pound (active) of polymer Irwin: $1.10 Mallard: $1.25 McDowell: $1.40
Thickening	
Thickening polymer dose	15 lb per dry ton (active)
Dewatering	
Dewatering polymer dose	25 lb per dry ton (active)
Disposal	
Dewatered Solids Land Application	$15.66 per wet ton
Fuel Adjustment Fee for Land Application	$3.00 per wet ton
Transport liquid solids from Vest WTP to Franklin WTP	$0.0321 per gallon
Liquid Solids Removal from Lee S. Dukes WTP lagoon	$0.0449 per gallon

O&M unit costs for each residuals unit process and cost category (i.e., labor, power, polymer, natural gas, maintenance) were developed and were combined to develop overall O&M unit costs (e.g., $/dry ton raw material) for each management option. Solids loading rates for this analysis were based on annual average day solids production.

Annual O&M costs were projected up to year 2035, assuming that all facilities for each alternative were constructed by year 2016, without phased implementation. O&M costs are shown for each alternative in the remaining sections of this report.

Table 9-3 summarizes the O&M costs developed for each process, based on current operating costs for power, labor, and chemicals. For equipment not currently installed at CMUD facilities, information provided by manufacturers and observed at similar facilities was also utilized for this analysis. Each value in Table 9-3 represents the unit cost to treat 1 dry ton of solids entering that specific unit process.

Table 9-3 Unit Operating Cost Summary

<table>
<tr><th rowspan="2">Alternative</th><th>1-1</th><th>3-4</th><th>3-6</th><th>3-7</th><th>3-8</th><th>4-4</th><th>4-12</th><th>3+4-1</th><th>3+4-2</th><th>3+4-3</th></tr>
<tr><th>Maintain Current Operations</th><th>McAlpine Thermal Hydrolysis</th><th>McAlpine Thermal Hydrolysis + Irwin Pumping</th><th>Electrical Lysis at all WWTPs</th><th>McAlpine Thermal Hydrolysis + ELP at Other WWTPs</th><th>McAlpine Thermal Drying</th><th>McAlpine Thermal Drying + McDowell Solar Drying</th><th>McAlpine Thermal Hydrolysis + Drying</th><th>McAlpine Thermal Hydrolysis + Drying + Irwin Pumping</th><th>McAlpine Thermal Hydrolysis + Drying + Electrical Lysis at Other WWTPs</th></tr>
<tr><td rowspan="2">Centrifuge WAS Thickening</td><td>McAlpine: $86.3</td><td colspan="4"></td><td colspan="2">McAlpine: $86.3</td><td colspan="3"></td></tr>
<tr><td colspan="10">Mallard: $179.4</td></tr>
<tr><td rowspan="2">Gravity Belt Thickening</td><td colspan="2">Irwin: $66.8</td><td></td><td colspan="7">Irwin: $66.8</td></tr>
<tr><td colspan="10">McDowell: $70.4</td></tr>
<tr><td>Centrifuge Pre-Dewatering</td><td></td><td>McAlpine: $70.63</td><td>McAlpine: $70.63</td><td></td><td>McAlpine: $70.63</td><td></td><td></td><td colspan="3">McAlpine: $70.63</td></tr>
<tr><td>Thermal Hydrolysis Process (THP)</td><td></td><td>McAlpine: $24</td><td>McAlpine: $23.29</td><td></td><td>McAlpine: $24.05</td><td></td><td></td><td>McAlpine: $24.05</td><td>McAlpine: $23.29</td><td>McAlpine: $24.05</td></tr>
<tr><td>Electrical Lysis Process</td><td rowspan="4"></td><td rowspan="4"></td><td rowspan="4"></td><td>McAlpine: $22.1</td><td></td><td rowspan="4"></td><td rowspan="4"></td><td rowspan="4"></td><td rowspan="4"></td><td></td></tr>
<tr><td></td><td>Irwin: $30.97</td><td>Irwin: $30.97</td><td>Irwin: $30.97</td></tr>
<tr><td></td><td>Mallard: $35.47</td><td>Mallard: $35.47</td><td>Mallard: $35.47</td></tr>
<tr><td></td><td>McDowell: $40.28</td><td>McDowell: $40.28</td><td>McDowell: $40.28</td></tr>
<tr><td>Anaerobic Digestion</td><td>McAlpine: $10.8</td><td></td><td></td><td rowspan="4"></td><td rowspan="4"></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="3">Irwin: $16.8</td><td colspan="3">Irwin: $16.8</td><td></td><td></td></tr>
<tr><td></td><td colspan="3">Mallard: $11.7</td><td colspan="4">Mallard: $11.7</td><td></td></tr>
<tr><td></td><td colspan="3">McDowell: $7.1</td><td>McDowell: $7.1</td><td></td><td colspan="2">McDowell: $7.1</td><td></td></tr>
<tr><td>Centrifuge Dewatering</td><td>McAlpine: $49.9</td><td>McAlpine: $39.5</td><td></td><td></td><td>McAlpine: $39.5</td><td colspan="2">McAlpine: $49.9</td><td></td><td>McAlpine: $39.5</td><td>McAlpine: $39.5</td></tr>
<tr><td></td><td colspan="10">Mallard: $110.7</td></tr>
<tr><td>Belt Filter Press Dewatering</td><td colspan="2">Irwin: $35.3</td><td></td><td colspan="7">Irwin: $35.3</td></tr>
<tr><td></td><td colspan="10">McDowell: $52.5</td></tr>
<tr><td>Thermal Dryer</td><td></td><td></td><td></td><td></td><td></td><td colspan="2">McAlpine: $174.7</td><td>McAlpine: $105.9</td><td>McAlpine: $98.4</td><td>McAlpine: $105.9</td></tr>
<tr><td>Solar Drying</td><td></td><td></td><td></td><td></td><td></td><td></td><td>McDowell: $87.4</td><td></td><td></td><td></td></tr>
<tr><td>Dewatered Solids Land Application</td><td colspan="5">McAlpine: $101.4</td><td rowspan="4"></td><td rowspan="4"></td><td rowspan="4"></td><td rowspan="4"></td><td rowspan="4"></td></tr>
<tr><td></td><td colspan="2">Irwin: $103.7</td><td></td><td colspan="2">Irwin: $103.7</td></tr>
<tr><td></td><td colspan="5">Mallard: $93.3</td></tr>
<tr><td></td><td colspan="5">McDowell: $116.6</td></tr>
<tr><td>Residuals Pumped to McAlpine from Irwin</td><td></td><td></td><td>McAlpine: $4.42</td><td></td><td></td><td></td><td></td><td></td><td>McAlpine: $4.42</td><td></td></tr>
</table>

*see Section 6 for a detailed description of each alternative.

As shown in Table 9-3, the costs of final disposal vary between the alternatives. This is due to the different degrees of dewatering achieved by centrifuges and belt filter presses at the individual plants.

9.2.3 O&M Net Present Cost

Net present operating and maintenance costs were developed based on an assumed inflation rate. The discount rate was instead obtained from the Office of Management and Budget for a 20 year planning period. Table 9-4 summarizes the parameters used.

Table 9-4 Net Present Value O&M Cost Assumptions

Parameter	Rate
Inflation Rate	3.0%
Discount Rate	0.8%

Present worth costs are reported in January 2013 dollars. Construction of the proposed facilities was assumed to be completed by 2016, which would be the first year of operation. Life cycle operating costs were developed for each of the management strategies from 2016 through 2035.

9.3 Framework for Non-Monetary Evaluation of Alternatives

9.3.1 Evaluation Criteria and Performance Measures

Cost is only one of many factors that must be considered in the selection of an alternative. Equally important are factors such as long-term sustainability of the biosolids and residuals management program, the number and variety of distribution outlets, ability to react to future changes in environmental regulations, public perception of treatment processes and biosolids products, and adaptability of the program to growth and other changes in the area.

9.3.2 Alternatives Ranking

The non-cost evaluation criteria presented in **Table 9-5** were developed through discussions with CMUD staff and reflect the array of priorities identified by CMUD and their significance relative to each other.

A simple ranking process was used to rate alternatives based on non-cost factors. This method consisted of developing weighting factors on a 1 to 5 scale to be assigned to each criterion listed in Table 9-5, and rating the performance of each alternative in meeting each criterion on a 1 to-10 scale. For each criterion, the 1-5 weight factor was then multiplied by the 1-10 rating to generate a score, which was summed over all the criteria to establish an overall score for the alternative.

The weighting factors for each criterion were established by surveying CMUD staff. Table 9-5 summarizes the results of the weighting exercise in which reliability and O&M costs received the highest weights, while capital cost and regionalization ranked the lowest.

CDM Smith staff then rated the performance of each alternative by assigning a 1 to 10 score to each criterion. A "1" signifies that the alternative performs poorly, while a "10" signifies excellent performance.

Table 9-5 Weighting Factors for Alternatives Evaluation Criteria

Criteria	Description	Weighting Factor
Long Term Viability/ Sustainability	Long-term viability is defined as the ability to meet the biosolids and residuals handling, treatment, and disposal/end use requirements throughout the planning period. This includes identifying technologies that are durable and are capable of meeting anticipated regulatory changes, ensuring that there is a sustainable market for the biosolids end product, and quantifying potential changes in energy costs that may impact treatment options, etc.	5.0
Reliability	Ability of a given treatment process to consistently perform in accordance with the intended design and function of the system with minimal down time. A reliable system aims at optimizing its performance. Systems that require extensive equipment may be considered less reliable than other less equipment or chemical dependent systems.	5.0
O & M Cost	Operation and maintenance costs compared to current practices. Includes energy consumption required for process.	5.0
Process Maintainability	The ease in which a treatment process is maintained. Accessibility of equipment, required spare parts inventory, availability of parts, and special tools or skill requirements are associated with the maintainability of a treatment system.	4.5
Impact on Existing Facilities	Potential impacts on existing processes, including potential for air quality/odor impacts during processing.	4.0
Proven Technology	This criterion relates to utilizing technologies with a proven history of success. This includes technology that may not yet be widely utilized in the US but have a proven history of success worldwide.	3.5
Operability/ Ease of Use	The ease of operation of a treatment system. The amount and type of operator attention and the degree of automation are both aspects of the operability of a treatment system. Some alternatives may require a high degree of control for efficient operation, while others may require less.	3.5
Risk Management	This criterion relates to how much risk is associated with a given alternative and the degree to which the risk can be managed (i.e., is the market for the product end use guaranteed, are all cost impacts (current and future) fully understood and captured, etc.)	3.0
Side Stream Impacts	Some of the biosolids management technologies (such as anaerobic digestion technologies) can generate return flows that have high concentrations of ammonia and phosphorous. This high nutrient loading may upset the liquid treatment and may result in high levels of nitrogen and phosphorous in the effluent. However, while the sidestream associated to dewatering is a challenge, it is also an opportunity for nutrient recovery. Once the nutrients are out of the solids stream, they are easier to recover.	3.0
Public Perception/ Acceptance	This criterion includes the positive or negative impact each alternative has on the surrounding community including residents and businesses near the WWTP and at biosolids land application locations. Public acceptance includes environmental, aesthetic, and ergonomic factors such as traffic, noise, odor, and visual appeal	2.0
Flexibility/ Adaptability	Ability of a proposed alternative to accommodate the varying conditions of flow, waste load, maintenance service needs, etc., and still meet regulatory permit requirements and being able to adapt based on current conditions. Some alternatives may require major additional capital expenditures that hinder cost-effective improvements should permit conditions or other factors such as flows and loadings to the facilities change.	2.0

Criteria	Description	Weighting Factor
Resource Recovery Opportunities	Optimization of all potential resource recovery opportunities can contribute to a successful policy for disposal of the final product.	2.0
Partnerships and Regionalization	Ability to create a regional facility with the intent to incur several benefits, such as reduced capital cost by providing a single facility, single location for collection of end product, more cost effective and simpler O&M, holistic approach to biosolids treatment and disposal.	1.0
Capital Cost	Opinion of Probable Construction Cost in year 2013 dollars.	1.0

The evaluation criteria, criteria weighting and the ratings of each alternative with respect to the criteria were entered into a decision model to identify the preferred alternative from a qualitative perspective. CDM Smith utilized a proprietary software package, Criterion Decision Plus (CDP), to facilitate the analyses. While the calculations could be conducted manually or via spreadsheet, CDP normalizes the data to allow easy manipulation of the data and results, and also provides the ability to conduct certain sensitivity analyses.

The model provides a score of 0 to 1 (1 being the best), with the highest scored alternative deemed to be the preferred alternative on a qualitative basis. The model also calculates the level of certainty that this outcome would be the preferred choice. The results are discussed in the following section.

The following equation summarizes the scoring methodology:

$$\text{Overall Non-Monetary Score} = \sum \frac{(w_j - 1)}{\sum (w_i - 1)} \frac{R_j}{10}$$

In this equation, the overall non-monetary score is the total number of rating points received from each criterion. The higher overall scores represent the most favorable alternatives. The parameter w_j represents the 1 to 5 weight assigned to criterion "j", and R_j represents the individual 1-10 rating score assigned to the alternative for the criteria "j". The multiplication was carried out for each individual criterion, and then the scores were added together. The summed results were then ranked highest to lowest with the highest ranked alternative being the most favorable alternative. The results of the non-cost evaluation are presented in Section 19.

9.3.3 Greenhouse Gas Emissions

The lifecycle greenhouse gas (GHG) emissions associated with each management alternative were estimated using nominal assumptions about the treatment processes and disposal outlets involved. GHG emissions are reported in metric tons of CO2 equivalents (CO2e). A typical passenger vehicle will generate approximately five metric tons CO2e of emissions during the course of a year (U.S. EPA, 2012).

If the carbon in biosolids were simply converted to carbon dioxide without effort or other energy inputs, the net greenhouse gas addition would be zero. However, every biosolids management process involves other energy inputs and outputs resulting in a positive or negative effect on the short cycle carbon balance.

Most of the carbon in biosolids ultimately becomes carbon dioxide in the atmosphere. For example, if methane is generated and burned in a flare or engine it is converted back to carbon dioxide. Carbon dioxide from biosolids is termed 'short cycle' carbon. It originates from photosynthetic activities occurring a short time before it is incorporated into biosolids. The carbon dioxide is simply being returned to the same atmosphere from which it was removed by photosynthesis, causing no net increase in greenhouse gas emissions. There are some exceptions:

- Methane is a more potent greenhouse gas than carbon dioxide, so fugitive emissions of unburned methane have a net greenhouse gas effect.
- Some carbon from biosolids may be sequestered in soil or a landfill resulting in a net removal of greenhouse gas.
- Nitrous oxide from the nitrogen in biosolids is also a potent greenhouse gas. A small amount is released during land application.

'Fossil' or 'long cycle' carbon from fossil fuel is a net addition to greenhouse gas because it was removed from the atmosphere in a previous geological era and increases the amount of carbon dioxide in the atmosphere today.

It is common practice to classify GHG emissions into "scopes" representing different sources of emissions. The scopes are listed below, with elements of each that are applicable to this project.

- <u>Scope 1</u> – includes all emissions generated inside the plant, consisting primarily of fugitive methane and N_2O emissions.
- <u>Scope 2</u> – Accounts for off-site emissions associated with electricity usage.
- <u>Scope 3</u> – All emissions generated outside the plant are included in Scope 3. The principal component of scope 3 emissions in this study is transportation of biosolids to final disposal.
- <u>Scope 3 offsets</u> – Offsets represent processes that effectively remove carbon from the atmosphere. The majority of the organic carbon in wastewater originated in the atmosphere, was incorporated into plants through photosynthesis, and consumed by animals and people. Some biosolids disposal outlets, such as land application and composting, render this carbon unavailable for an extended period of time, effectively sequestering it in the soil. As such, final disposal of biosolids may offset some or all of the GHG emissions associated with processing.

The GHG emissions associated with each alternative were approximated using a model. The model is built on Excel spreadsheets and includes the following components:

- Biosolids percent solids is the primary variable entering the model.
- Mass balance.
- Energy associated with each process normalized to KWh per wet ton and dry ton.

- Energy expenditure.
- Energy off-set from energy saved by beneficial use of product.

Model Inputs

Table 9-6 shows the resources expended for each biosolids process, expressed on a common basis of energy and greenhouse gas emission rates. The table also shows the greenhouse gas emissions and off-sets occurring at the point of application. The quantities of each resource used for each alternative are calculated outside of this model.

Table 9-6 Energy and GHG Values Used in Model

	Units	Energy KWh equivalent	GHG tons CO_2 equivalent	Notes
Resources Used in Processing				
Nat. gas	mmbtu	293	0.0603	
Electricity	KWh	1.0	0.000608	U.S. EPA eGRID Emission and Generation Resource Integrated Database
Diesel	Gallon	39.6	0.0119	
Ammonia	ton	9,000	2.82	Calculated from (Worrel et al 2000)
NaOH	Ton	2648	1.48	Inventory of U.S. Greenhouse Gas Emission Sources and Sinks 1990-2005
Effects at Application Site				
N2O emitted	Tons CO2 equiv/ton N applied		0.139	Eichner: 0.03 % as N IPPC Third Assessment Report: 1 ton N2O equivalent to 293 tons CO2
C sequestration	Ton of Volatile Solids applied		0.183	0.05 tons Carbon sequestered over 100 years

Model Outputs

The model output is a positive or negative number representing the net tons of carbon dioxide equivalent added to or removed from the atmosphere per year for each scenario. Each output is a balance of positive factors (GHG equivalents emitted) and negative factors (GHG equivalents prevented or off-set due to beneficial re-use of biosolids).

Section 10

Alternative 1-B Evaluation: Maintain Current WTP Operations

10.1 Overview

Alternative 1-B represents continued use of the existing facilities and operational practices at CMUD's WTPs. A general overview of these facilities is presented in Section 2.

The analysis in this Section serves as a point of reference for the remaining alternatives, which involve additional modifications and associated capital improvements to the residuals treatment process. The capital expenditures associated to Alternative 1-B are instead limited to expansions in the current unit processes that are required to treat and handle future solids projections. The replacement of existing equipment that is expected to reach the end of its useful life within the planning period is not included in the cost analyses, except for major rehabilitation work identified by CMUD as critical.

Current operations at each WTP are analyzed independently first, followed by an overall evaluation of capital improvements, O&M costs and a qualitative analyses for the entire WTP system.

10.2 Maintain Current Operations at Franklin WTP and Vest WTP

10.2.1 Franklin WTP Process Description

The Franklin WTP treats residuals generated at this facility, in addition to those hauled from the Vest WTP. On average, the transfer operation from Vest WTP corresponds to 10 truckloads of approximately 6,400 gallons at 1.5 % solids each per week. Process flow diagrams for Franklin WTP and Vest WTP are presented in **Figure 10-1** and **Figure 10-2** for reference.

Table 10-1 and **Table 10-**2 summarize the forecasted solids production at Franklin WTP and Vest WTP under moderate and aggressive growth scenarios. From comparison between these two tables, the loading forecasts in year 2035 under the moderate growth scenario correspond to approximately year 2025 projections under the aggressive growth scenario. While the operating schedule and size may be reduced under the moderate growth scenario, the number of units required for each process would not change with respect to the aggressive growth scenario. For this reason, only the latter is evaluated in the following.

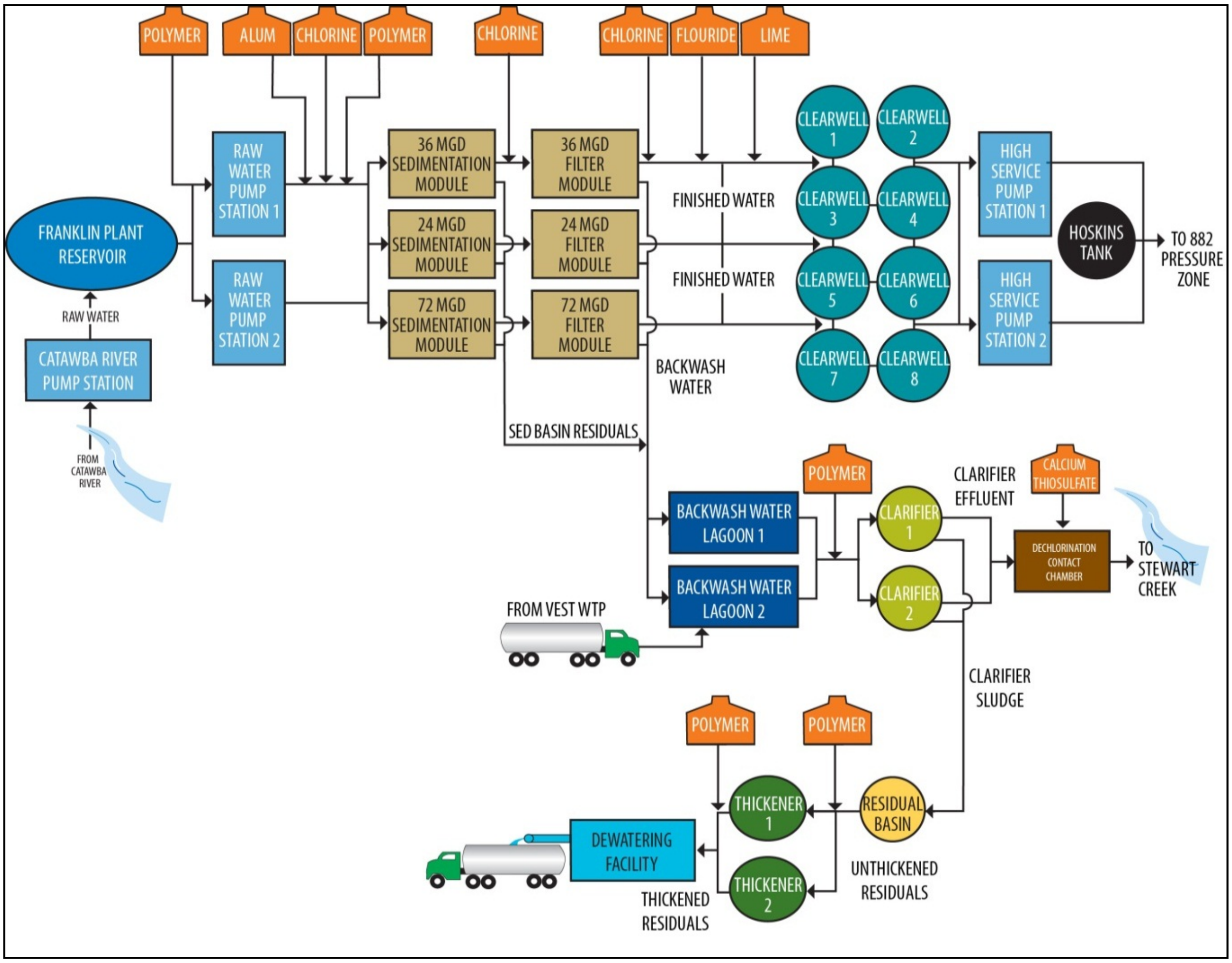

Figure 10-1
Franklin WTP Process Flow Schematic

10.2.2 Franklin WTP Existing Facilities Capacity Evaluation

Filter Backwash Clarifiers

Flow from the backwash lagoons enters the splitter box where it is divided between two backwash clarifiers, 70 feet and 100 feet in diameter. From these units, the solids are pumped to the residuals basin, while clarifier effluent water is discharged by gravity to an unnamed tributary to Stewart Creek.

Table 10-3 presents an evaluation of the available processing capacity of the existing clarifiers. It includes the feed hydraulic loading rate (HLR) to the two units and the installed total surface area available for processing the receiving solids. The size of filter backwash clarifier required is controlled by the HLR. Under year 2035 max month conditions, it is forecasted that each of the units could receive the entire load without being overload, in the event that one clarifier must be taken out of service.

For each clarifier, the installed surface overflow rate for year 2035 is lower than the expected allowable overflow rate of 600 gpd/ft^2. Therefore, no additional clarifiers are required for future conditions.

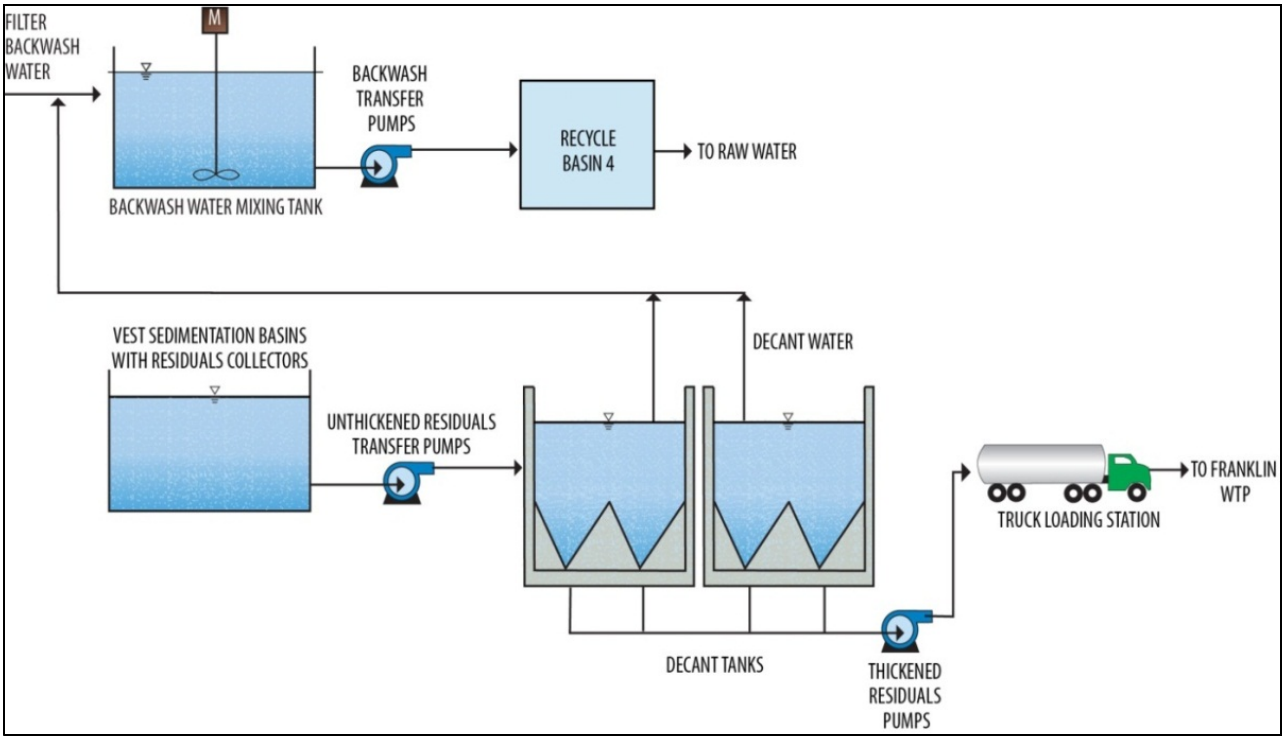

Figure 10-2
Vest WTP Process Flow Schematic

Table 10-1 Franklin WTP Mass Balance for Year 2035 Max Month Conditions (Aggressive Scenario)

Year	Annual Average Flow (mgd)	Max Month Solids Loading Rate (DT/d)		
		Franklin WTP	Vest WTP	Total
2015	78.1	6.1	1.4	7.5
2025	95.2	7.4	1.8	9.2
2035	116.1	9.0	1.8	10.8

Table 10-2 Franklin WTP Mass Balance for Year 2035 Max Month Conditions (Moderate Scenario)

Year	Annual Average Flow (mgd)	Max Month Solids Loading Rate (DT/d)		
		Franklin WTP	Vest WTP	Total
2015	76.5	6.0	1.4	7.4
2025	87.0	6.8	1.8	8.6
2035	98.1	7.6	1.8	9.4

Table 10-3 Backwash Clarifiers Facility

Year 2035 Max Month Feed Loading Rate		
Total Feed HLR (gpd)	2,167,800	
Backwash Clarifiers Characteristics		
Quantity	1	1
Diameter, ft	70	100
Installed Surface Area (ft^2)	3,850	7,850
Surface Overflow Rate (gpd/ft^2)	563	276
Existing Redundancy	One Unit	

Gravity Thickeners

One 45-foot diameter and one 55-foot diameter thickeners receive the unthickened residuals from the residuals basin, at a solids concentration of approximately 1.1 percent solids. While one unit receives flow from the residuals basin, solids from the other tank are withdrawn and fed to the BFPs. The receiving thickener is selected by the operators.

Gravity thickeners serve a similar function as the backwash clarifiers, concentrating influent solids and removing water. However, thickeners are sized based on a SLR not to exceed 5 $lb/day/ft^2$. As shown in **Table 10-4**, both thickeners would need to be operated simultaneously for year 2035 max month conditions, as the combined SLR is 4.6 $lb/day/ft^2$, slightly below the maximum recommended value. Therefore, operations in the future at max month conditions would need to be modified from the current approach to load one thickener while withdrawing solids from the other one, unless a new additional unit is provided.

Table 10-4 Gravity Thickeners Facility

Quantity	1	1
Diameter, ft	45	55
Installed Surface Area (ft^2)	1,590	2,376
Year 2035 Max Month Feed SLR (dry lb/day)	18,000	
Combined SLR (dry $lb/day/ft^2$)	4.6	
Existing Redundancy	None	

Belt Filter Press Dewatering

From the thickeners, sludge is pumped to the dewatering system consisting of three 2-meter BFPs, of which the two older units, BFP 1 and BFP 2, were rebuilt in 2009 and are not typically operated. The newer BFP currently runs approximately 40 to 45 hours per week based on four 10 hour shifts, to supply a dewatered cake with a total solids concentration of 23 to 27 percent solids.

A hydraulic processing capacity of 170 gpm and a solids processing capacity of 1,700 lb/hr were chosen to remain within typical values referenced in the literature, as summarized in **Table 10-5.** Firm capacity with one unit is required to process max month loadings from Franklin WTP and Vest WTP in year 2035, operating 120 hours per week (e.g., 24x5 operating schedule), as summarized in **Table 10-6**.

Table 10-5 Belt Filter Press Dewatering Facility

Number of Existing Units (Total)	3
Belt width (m)	2
Hydraulic Processing Capacity (gpm)	170
Solids Processing Capacity (lb/hr)	1,700
Feed solids concentration (% TS)	2%
Dewatered solids concentration (% TS)	25%

Table 10-6 Belt Filter Press Dewatering – Required No. Units

Year	2015	2025	2035
Operating Schedule (hours per week)	120		
Operating Schedule (hours per days)	24x5		
Max Month Feed Loading Rate			
Feed SLR (lb/hr)	875	1,075	1,260
Feed HLR (gpm)	90	110	125
Processing Capacity Req'd For Year 2035			
Number of Operating Units	1		
Total Solids Processing Capacity (lb/hr)	1,700		
Total Hydraulic Processing Capacity (gpm)	170		

10.3 Maintain Current Operations at Lee S. Dukes WTP

10.3.1 Lee S. Dukes WTP Process Description

Table 10-7 summarizes the forecasted solids production at Lee S. Dukes WTP under the aggressive growth scenarios. Moderate growth projections are slightly lower, as presented in Section 3, and would not change the equipment requirements. A process flow schematic for the Lee S. Dukes WTP is presented in **Figure 10-3** for reference.

Table 10-7 Max Month Process Feed Rate (Aggressive Scenario)

Year	Annual Average Flow (mgd)	Max Month Solids Loading Rate (DT/d)
2015	18.0	1.0
2025	20.9	1.2
2035	24.2	1.4

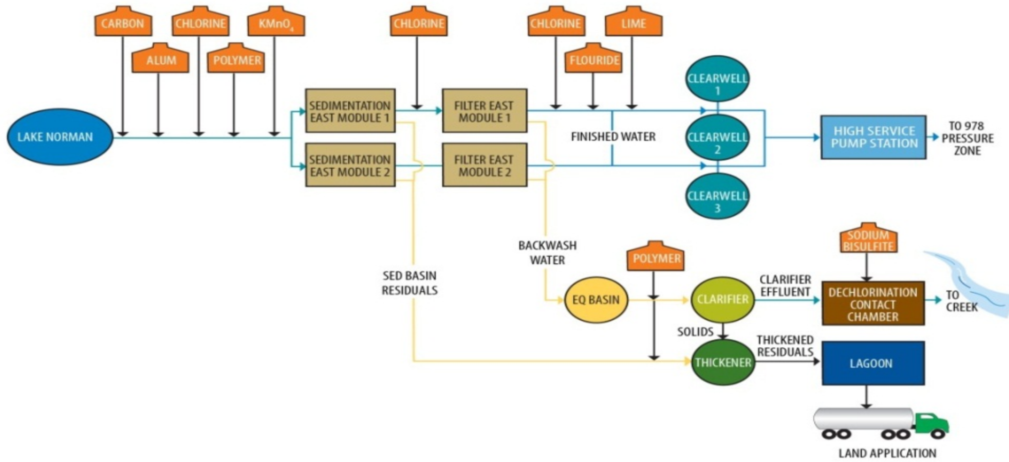

Figure 10-3
Lee S. Dukes WTP Process Flow Schematic

10.3.2 Lee S. Dukes WTP Existing Facilities Capacity Evaluation

Filter Backwash Clarifier

Table 10-8 presents an evaluation of the available processing capacity of the existing wash water clarifier basin. The size of the clarifier required is controlled by the HLR, which is shown in this table with the installed total surface area available for processing the receiving solids. The installed surface overflow rate for year 2035 is lower than the expected allowable overflow rate of 600 gpd/ft^2. Therefore, it is concluded that the clarifier is sufficient to receive the entire future load, although no redundancy is provided on site.

Table 10-8 Backwash Clarifiers Facility

Quantity	1
Diameter, ft	85
Installed Surface Area (ft^2)	5,675
Year 2035 Max Month Feed HLR (gpd)	255,000
Surface Overflow Rate (gpd/ft^2)	45
Existing Redundancy	None

Gravity Thickener

As shown in **Table 10-9**, the 50-foot diameter gravity thickener is adequately sized for year 2035 max month conditions, with a SLR is 1.1 lb/day/ft^2, below the maximum recommended value of 5 lb/day/ft^2. No additional units are required unless redundancy is desired in the future.

Table 10-9 Gravity Thickening Facility

Quantity	1
Diameter, ft	50
Installed Surface Area (ft^2)	1,960
Year 2035 Max Month Feed SLR (dry lb/day)	2,130
SLR (dry lb/day/ft^2)	1.1
Existing Redundancy	None

Lagoon

The residuals stored in the sedimentation lagoon at Lee S. Dukes WTP are pumped out and land applied on the existing plant site at approximately three to four percent solids, three to four times a year. The estimated annual average solids production for year 2035 will not increase substantially, from 0.8 to 1.1 dry tons per day. At a solids concentration of 3.5%, the existing lagoon will require to be emptied every 110 days, which is consistent with current operations. Therefore, no additional expansion of the existing lagoon is anticipated.

10.4 Total Life Cycle Cost for Alternative 1-B: Maintain Current Operations at WTPs

Table 10-10 summarizes the O&M costs required at all WTPs to maintain current operations for the planning period. No capital costs for installation of new equipment are required under this alternative to meet future projections for residuals production. The analysis does not consider replacement of equipment approaching its end of life within the planning period. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period, and therefore coincides with the O&M cost for this Alternative 1-B.

Table 10-10 Summary of Capital and O&M Costs for Alternative 1-B

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
Franklin WTP, Vest WTP and Lee S. Dukes WTP	$0.00	$0.00	$0.00
Subtotal Direct Construction Costs	$0.00	$0.00	$0.00
Total Capital Cost			**$0.00**
O&M Cost			**20-Year NPV ($M)**
Dewatering at Franklin WTP			$3.18
Vest WTP and Franklin WTP Dewatered Solids Land Application			$5.12
Vest WTP Liquid Solids Transportation to Franklin WTP			$4.54
Lee S. Dukes WTP Liquid Solids Land Application			$2.33
Total Net Present O&M Cost			**$15.16**
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			**$15.16**

Section 11

Alternative 11-1: WTP Dewatering & Storage Alternative Evaluation

11.1 Overview

Alternative 11-1 consists of implementing the following improvements:

- **Franklin WTP**: A new storage facility at Franklin WTP to avoid transfer of dewatered solids to Irwin.
- **Vest WTP**: The residuals generated at Vest WTP would be pumped to Franklin WTP through a new force main, instead of being transported by truck.
- **Lee S. Dukes WTP**: Lee S. Dukes WTP would dewater on site the residuals removed from the existing lagoon prior to land application. A new storage facility for dewatered solids would be constructed.

A summary of these operations is summarized in **Table 11-1**.

Table 11-1 Strategy 11 WTP Residuals Dewatering and Pumping Alternatives

WTP	Franklin	Vest	Lee S. Dukes
Alternative 11-1	Dewater On-Site and Provide Dewatered Solids Storage	Liquid residuals pumped to Franklin	Dewater On-Site and Provide Dewatered Solids Storage

11.2 Alternative 11-1: Facilities Required

11.2.1 Franklin WTP Dewatered Cake Storage

Instead of hauling dewatered cake to Irwin, a new Dewatered Solids Storage Facility would be located southeast of the dewatering building at Franklin WTP, as shown in **Figure 11-1.** The new facility would consist of a covered concrete pad and would be 220 feet in length by 150 feet in width. Trucks would transfer dewatered cake to the storage area from the Dewatering Building. A front-end loader would then be used to move the cake into piles. The same equipment would be used to load trucks with residuals for transport to end use.

The following criteria were used to size the storage area:

- Ability to store dewatered cake from Franklin WTP and Vest WTP (25% solids).
- Storage requirements based on annual average loading rates projected for year 2035.
- Batch height of six feet.
- Assumed maximum storage duration of 90 days.

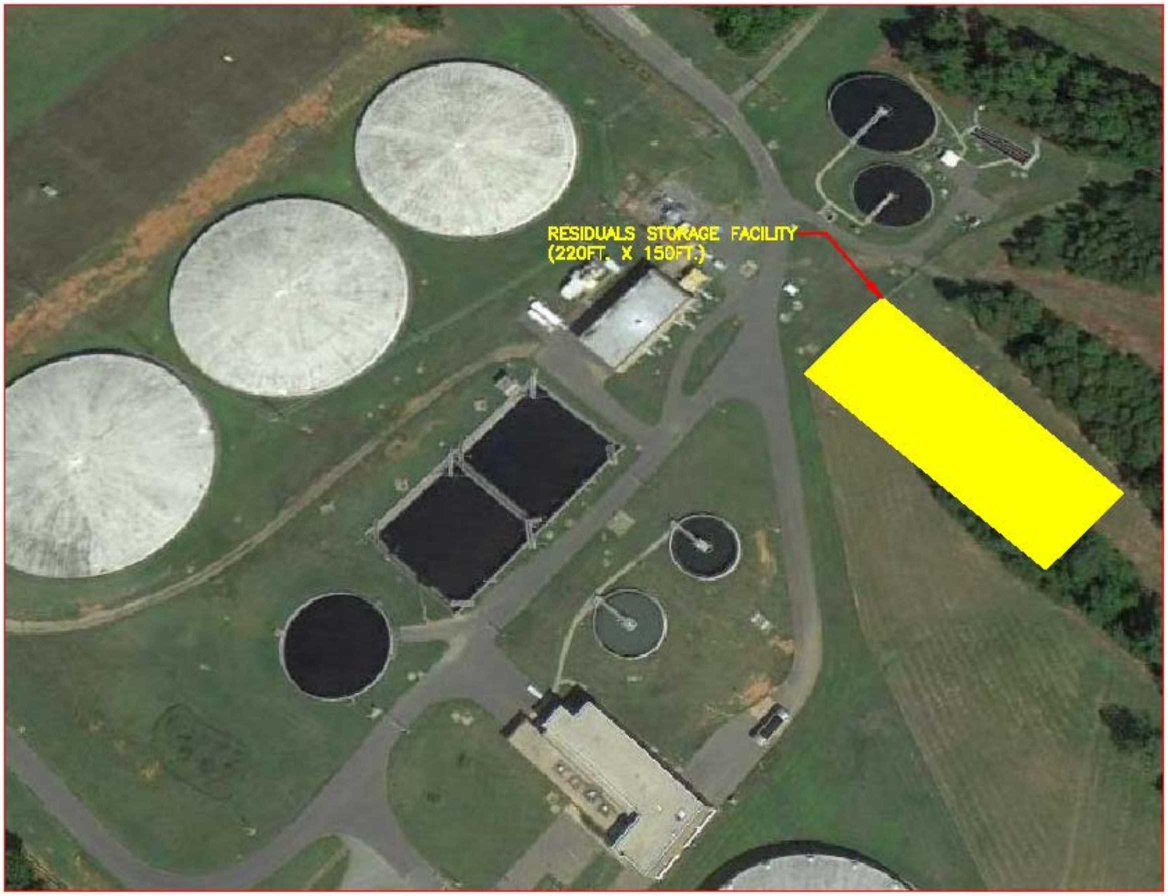

Figure 11-1
Franklin WTP Dewatered Cake Storage

Assuming a density of 60 lb per cubic foot (lb/cft), the existing Dewatered Solids Storage Facility can provide storage for approximately 3,000 wet tons. This facility would allow storing the projected annual average production of dewatered cake for year 2035 of 31.6 wet tons per day for 90 days. This amount includes 26.8 wet tons per day from Franklin WTP and 4.8 from Vest WTP at 25% solids.

11.2.2 Vest WTP Pumping Facilities

It is envisioned that the residuals from Vest WTP would be pumped at low solids concentrations (less than 1 percent) to Franklin WTP through a 4 inch new force main. The preliminary pipe route is estimated to be 2.7 miles long and is shown in **Figure 11-2** and would need to be evaluated during final design.

Two submersible wastewater pumps (including one standby unit) with a minimum capacity of 100 gpm are required to transfer the residuals to Franklin WTP. The same arrangement used for the three units currently installed in the Backwash Water Mixing Basin would be maintained, and it is possible that the existing pumps may continue to be used for this future application. This will be further evaluated during design, once the alignment for the force main if determined.

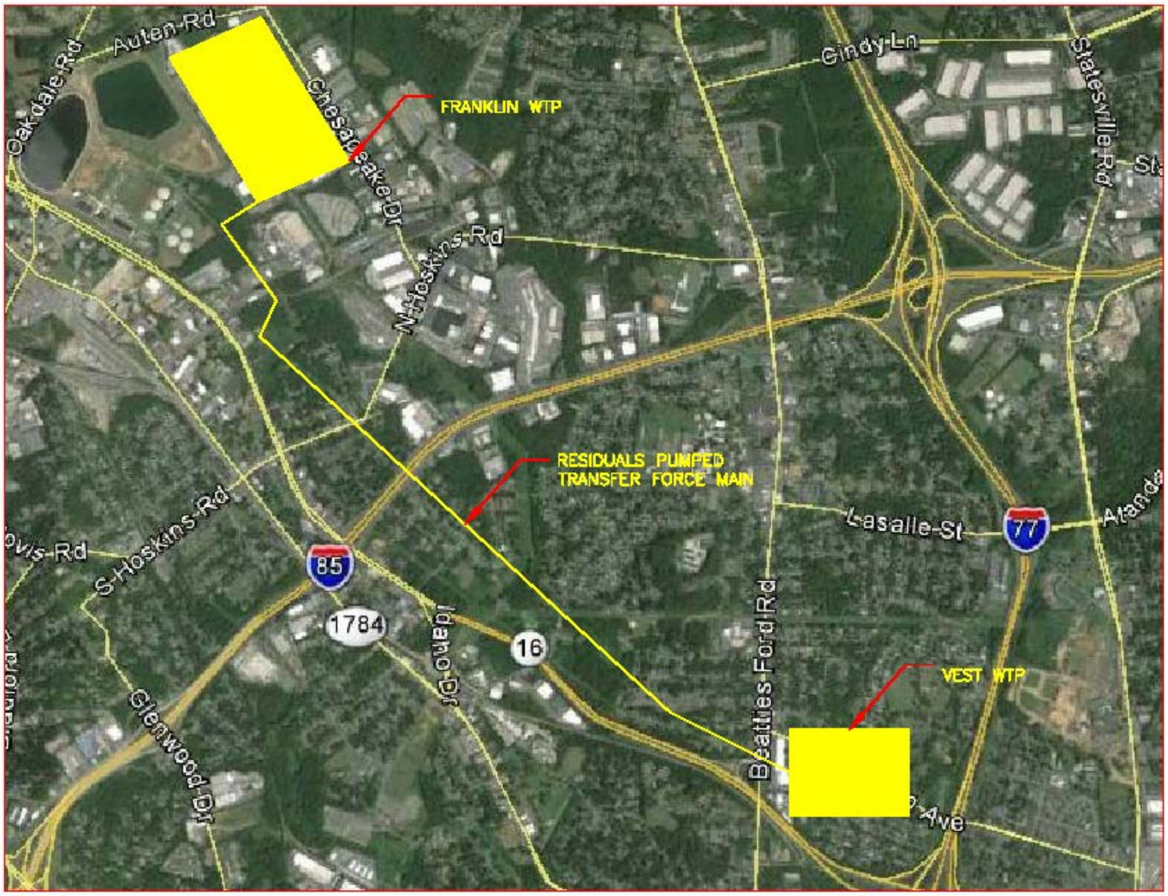

Figure 11-2
Vest WTP Residuals Force Main to Franklin WTP

11.2.3 Lee S. Dukes WTP Dewatering Facility

The solids from the lagoon are currently pumped on vacuum trucks and land applied. One 2-meter BFP is proposed to dewater the solids with performance characteristics summarized in **Table 11-2**. A dewatered cake solids concentration of 25 percent, similar to Franklin WTP's rate, was selected.

In order to dewater year 2035 solids, it would be necessary to operate the BFP for 3 days per week, 6 hours per day (total of 18 hours per week). A 12,000 gal holding tank will be provided for temporary storage of the liquid residuals pumped out from the lagoon. It is assumed that dredging and removal of the solids would continue to be operated using available equipment on site or would be contracted out, and the cost of these operations is not accounted for in this analysis.

Table 11-2 Dewatering Belt Filter Press Characteristics

Number of New Units (Total – No Standby)	1
Belt width (m)	2
Hydraulic Processing Capacity (gpm)	130
Solids Processing Capacity (lb/hr)	1,300
Feed solids concentration (% TS)	3.5%
Dewatered solids concentration (% TS)	25.0%

The BFP will be housed in a new dewatering building located south-east of the lagoon. As the solids are dewatered, cake will drop out of the belt filter press onto a belt conveyor. The end of the belt will be positioned over the top of a drive-through area for trucks.

11.2.4 Lee S. Dukes WTP Dewatered Cake Storage

A new Dewatered Solids Storage Facility would be constructed in the vicinity of the proposed dewatering building. The new facility would consist of a covered concrete pad and would measure 80 feet in length by 70 feet in width. Trucks would transfer dewatered cake to the storage area from the Dewatering Building. A front-end loader would then be used to move the cake into piles. The same equipment would be used to load trucks with residuals for transport to end use.

This facility would have a capacity of approximately 400 wet tons, corresponding to storage of the average residuals production projected for year 2035 for 90 days. **Figure 11-3** shows a site layout of the proposed facilities at Lee S. Dukes WTP.

11.3 Total Life Cycle Cost for Alternative 11-1: WTP Dewatering & Storage

A comprehensive life cycle of the capital improvements and O&M costs required at all WTPs to maintain current operations for the planning period is summarized in **Table 11-3**.

Table 11-3 Summary of Capital and O&M Costs for Alternative 11-1

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
Vest WTP Transfer Pumps	$0.08	$0.15	$0.23
Vest WTP Force Main to Franklin WTP	$-	$1.08	$1.08
Franklin WTP Dewatered Cake Storage Facility	$-	$3.18	$3.18
Lee S. Dukes WTP Dewatering Building	$0.42	$0.94	$1.36
Lee S. Dukes WTP Dewatered Cake Storage Facility	$0.00	$0.70	$0.70
Subtotal Direct Construction Costs	**$0.50**	**$6.04**	**$6.55**
Subtotal Indirect Construction Costs			**$4.51**
Total Capital Cost			**$11.06**
O&M Cost			**20-Year NPV ($M)**
Dewatering at Franklin WTP			$3.18
Vest WTP and Franklin WTP Dewatered Solids Land Application			$5.12
Vest WTP Liquid Solids Pumping to Franklin WTP			$0.16
Dewatering at Lee S. Dukes WTP			$0.42
Lee S. Dukes WTP Dewatered Solids Land Application			$0.57
Total Net Present O&M Cost			**$9.44**
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			**$20.50**

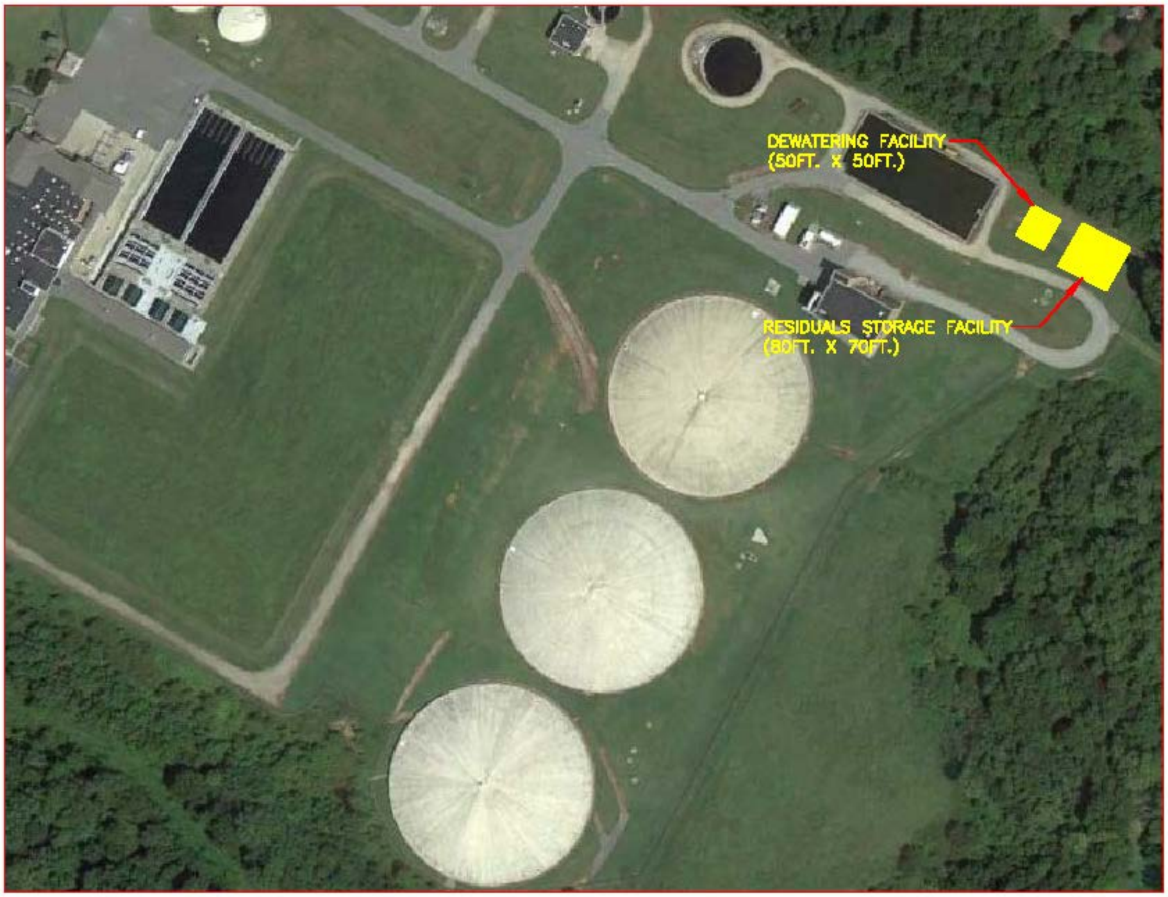

Figure 11-3
Lee S. Dukes WTP Proposed Dewatering and Storage Facilities

Section 12

Alternative 11-2: WTP Residuals Discharge to Sewer Alternative Evaluation

12.1 Process Description

Alternative 11-2 consists of implementing the following improvements:

- **Franklin WTP**: The residuals generated at Franklin WTP would be discharged to the sewer and receive further treatment/handling at Irwin Creek WWTP.
- **Lee S. Dukes**: The residuals generated at Lee S. Dukes WTP would be discharged to the sewer and receive further treatment/handling at McDowell WWTP.
- **Vest WTP**: The residuals generated at Vest WTP would be discharged to the sewer and receive further treatment/handling at Irwin Creek WWTP.

A summary of these operations is summarized in **Table 12-1**.

Table 12-1 Strategy 11 WTP Residuals Dewatering and Pumping Alternatives

WTP	Franklin	Vest	Lee S. Dukes
Alternative 11-2	Residual Discharge to Sewer; No Treatment On-Site	Residual Discharge to Sewer; No Treatment On-Site	Residual Discharge to Sewer; No Treatment On-Site

12.2 General Considerations

Discharge of WTP residuals to the sewer for further treatment at the WWTP is an economically attractive option from the perspective of water utilities. The risk that the WWTP operations will be negatively impacted, though, lends itself to the infrequency with which this practice is employed. Potential limiting concerns for a WWTP when it accepts WTP residuals include increased final suspended solids, decreased effective digester capacity, overloading of primary clarifier and sludge removal systems, and overloading of dewatering operations. In some cases, the receiving WWTP benefits from increased removal of suspended solids, additional phosphorus, and H2S conversion at the treatment plant. This section expands upon the these concerns.

12.2.1 Potential WWTP Impacts

Conveyance System Design

There are three primary means of transporting WTP residuals to a wastewater treatment facility: gravity sanitary sewers, pumping/forcemain systems, and truck hauling. Discharge to sanitary sewer is often less expensive than directly handling the residuals on site of the WTP. This option, however, provides the receiving wastewater facility the least amount of operational flexibility as all of the WTP residuals must be treated through the liquid stream process. There must also be adequate upstream discharge flow to ensure that the WTP residuals are flushed through the sewer system. Most importantly, the sewer system must have adequate capacity to receive the additional flows from WTPs.

Pretreatment Requirements

Discharge flow equalization is the most common requirement enforced by receiving WWTPs. Equalization restrictions may limit the time of day for discharge, or a maximum flow rate or solids concentration to be discharged over a period of time. Other pretreatment requirements can include regulating the quality of the discharge, which may include pH neutralization; homogenization of the waste stream to ensure uniform discharge concentration and character; limits on the total solids allowed to be discharged; and limitations on quality parameters such as heavy metals or components that may cause corrosion, odors, or other undesirable conditions.

Hydraulic Loading

Large volumes of liquid wastes generated by WTP processes over a short period of time should be equalized prior to discharge to prevent overloading of the gravity sewer. The hydraulic loading on unit treatment processes at the WWTP is usually not the controlling parameter when WTP residuals are introduced to the liquid treatment process train, unless the WWTP is a small one. Alternatively, discharge of WTP residuals directly to the solids handling processes brings up concern for hydraulic loading.

Solids Loading

In certain instances, metals present in WTP residuals can affect NPDES permit effluent limits. This situation is becoming more of a problem since most of the specific effluent requirements for metals in NPDES permits have daily limits. If a significant portion of the precipitates in the WTP residuals is in colloidal form, the solids pass through primary and/or secondary clarification at the WWTP. Another cause of increased metals concentrations in a WWTP effluent can be the resolubilization of metals that occurs when WTP residuals are processed in a WWTP's solids handling processes, and recycled flows from solids handling are returned to the liquid process train.

Most precipitates in WTP residuals are inert, though some have been observed to increase the amount of chemically precipitated phosphorus in a WWTP.

A common factor related to the discharge of WTP residuals to a WWTP is an increase in biosolids from the WWTP, with a corresponding decrease in the volatility of the biosolids.

Impact on Clarifiers

The addition of WTP residuals to the WWTP upstream of the primary clarifiers has been observed to cause a decrease in the primary sludge solids concentration and an increase in volume of liquid primary sludge to be pumped.

Decreased efficiency of solids settling in the secondary clarifiers has been correlated to the addition of WTP residuals to the WWTP influent. This necessitates the need for additional clarifier capacity, or the addition of polymer.

Digestion

Because WTP residuals can cause lime deposition, discharging softening residuals to a WWTP may adversely affect the performance of the anaerobic digester. If WTP residuals are added directly into the anaerobic digester, the temperature can fall because of the additional volume of inert material. Additional heating may be required in this event.

With the addition of WTP residuals, total solids in the digester increase. Gas production and total organic carbon (TOC), on the other hand, remained largely unaffected.

Digester pH has been observed to decrease in instances where alum residuals were added.

WTP residuals additional has also been shown to cause a decrease in the percentage of volatile solids in the digester because of the increased inorganic input. Inorganic phosphates in the digester were almost entirely precipitated by the aluminum present.

Dewatering

All thickening and dewatering equipment are sized based on solids loading. The introduction of WTP residuals may cause overloading of these facilities, depending on the quantity of residuals introduced and the existing WWTP loadings relative to the plant's design capacity.

Bio-Toxicity to Processes

Despite several findings reporting the apparent lack of impact of WTP residuals on biological treatment processes of WTP residuals on biological treatment processes, the metal contents of these residuals do pose some concerns. Metallic ions such as hexavalent chromium, cadmium, nickel, aluminum, and silver can hinder biological processes. These metals may also find their way into WTP residuals.

Effluent Toxicity

Increasing stringency of National Pollutant Discharge Elimination System (NPDES) has motivated some municipalities to adopt pretreatment regulations to limit the quality of discharges to sanitary sewers. Suspected causes of effluent toxicity at WWTPs receiving WTP residuals are:

Section 13

WTP Recommended Capital Improvements

13.1 Overview

This Section compares the WTP alternatives presented in Section 10 through 12 based on both cost and qualitative evaluations.

13.2 Cost Evaluation

Table 13-1 summarizes the opinion of probable construction cost and 20-year O&M costs for Alternatives 1-B (Maintaining Current Operations at WTPs) and 11-1 (WTP Dewatering & Storage).

Alternative 11-2, which considers direct discharge to sewers, was discussed in detail in Section 12 and was not considered for further evaluation. While processing WTP residuals at WWTPs has been done in the past and offers significant benefits associated to phasing out solids processing facilities at the WTPs, it can also present serious repercussions at WWTPs. Direct discharge to sewer would not alter the facility requirements for discharge from Vest WTP to Irwin Creek WWTP and from Lee S. Dukes to McDowell. Additional digester storage capacity would instead be required for the significant residuals loads generated at Franklin WTP, should they be processed at Irwin Creek WWTP. Further, as noted in Section 12, not all of the potential impacts at the WWTPs are quantifiable without further testing and investigations.

Table 13-1 Life Cycle Cost for WTP Alternatives

Evaluation Factor	Alternative 1-B Maintain Current Operations at WTPs ($ M)	Alternative 11-1 WTP Dewatering & Storage Alternative Evaluation ($ M)
Capital Cost	$0.00	$11.06
20-Year NPV O&M Cost	$15.16	$9.44
Total Lifecycle Cost	**$15.16**	**$20.50**

13.3 Recommendations

Since maintenance of current operations would not require expansion of the existing facilities, no capital cost associated to Alternative 1-B, while O&M costs are higher, as more solids would be hauled and disposed of. Alternative 11-1 requires capital improvements but also offers the following benefits:

- Reduced transportation of liquid solids from Vest WTP to final disposal.
- Reduced transportation of dewatered cake from Franklin WTP to Irwin Creek WWTP for storage.
- Ability to dewater and store dewatered cake on site at Lee S. Dukes prior to final disposal.

For these reasons, Alternative 11-1 is the recommended alternative for WTP operations.

Section 14

Alternative 1-1 Evaluation: Maintain Current WWTP Operations

14.1 Overview

Alternative 1-1 represents continued use of the existing facilities and operational practices at CMUD's WWTPs. A general overview of these facilities are presented in Section 4.

The analysis in this Section serves as a point of reference for the remaining alternatives, which involve additional modifications and associated capital improvements to the biosolids treatment process. The capital expenditures associated with Alternative 1-1 are instead limited to expansions to the current unit processes that are required to treat and handle future solids projections. The replacement of existing equipment that are expected to reach the end of its useful life within the planning period is not included in the cost analysis, except for major rehabilitation work identified by CMUD as critical.

Current operations at each WWTP are analyzed independently first, followed by an overall evaluation of capital improvements, O&M costs and a qualitative analysis for the entire WWTP system.

14.2 Maintain Current Operations at McAlpine Creek WWMF

14.2.1 McAlpine Creek WWMF Process Description

Table 14-1 summarizes the results of the mass balance for McAlpine Creek. A process flow schematic is presented in **Figure 14-1** for reference.

Table 14-1 McAlpine Creek WWMF Mass Balance for Year 2035 Max Month Conditions

	PS	PS Gravity Thickening Discharge	WAS	WAS Centrifuge Thickening Discharge	Anaerobic Digestion Feed	Anaerobic Digestion Effluent	Centrifuge Dewatered Cake
Total SLR (dry ton/day)	66.2	62.9	39.8	37.8	100.6	59.2	56.2
TS Concentration (%)	0.23%	5.30%	0.80%	5.10%	5.22%	3.07%	18.40%
Total HLR (gpd)	6,814,300	284,400	1,197,900	177,600	462,200	462,200	73,300
Total SLR (wet ton/d)	28,416	1,186	4,995	741	1,927	1,927	306

14.2.2 McAlpine Creek WWMF Existing Facilities Capacity Evaluation

Primary Sludge Gravity Thickening

Table 14-2 summarizes the characteristics of the four gravity thickeners receiving primary sludge from Sugar Creek WWTP and McAlpine Creek WWMF, while **Table 14-3** provides a comparison of required and available processing capacity.

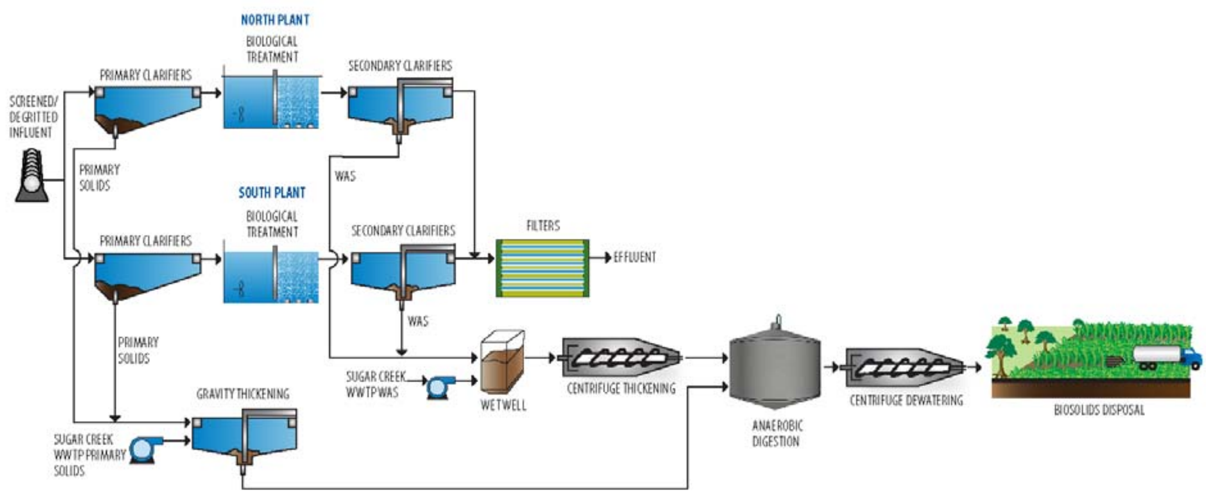

Figure 14-1
McAlpine Creek WWMF Process Flow Schematic

Table 14-2 Gravity Thickening Facility

Parameter	Original Gravity Thickeners	Additional Gravity Thickeners
Quantity	2	2
Diameter, ft	45	60
Installed Surface Area (ft^2)	3,180	5,655
Installed Total Surface Area (ft^2)	8,835	

Table 14-3 Projected Gravity Thickeners Loading Rate versus Installed Capacity

Year	Max Month Loading Rate		Required Total Surface Area (HLR Controlled) (ft^2)	Installed Total Surface Area (ft^2)
	Total Feed HLR (gpd)	Total Feed SLR (DT/day)		
2015	5,695,300	56.0	7,500	8,835
2025	5,894,800	59.0	7,800	
2035	6,814,300	66.2	8,970	

Table 14-3 includes the feed SLR and HLR to the four units and the total surface area required for processing the receiving solids for year 2035. The required surface area was estimated based on a maximum overflow rate of 760 gallons per day per square foot (gpd/ft^2)(HLR controlled) and a maximum loading rate of 25 pounds per day per square foot (lb/d-ft^2) (SLR controlled). These parameters are typical surface area design criteria for sizing gravity thickeners, as referenced in MOP 8.

Table 14-3 further compares the installed surface area with all four gravity thickeners in operation against the area required to treat the projected loading rate. The two values are substantially similar and therefore the capacity provided by the existing units is deemed sufficient, although no redundancy is provided.

WAS Centrifuge Thickening

A total of three centrifuges are available to thicken WAS from Sugar Creek WWTP and from the plant secondary clarifiers. Currently, two thickening centrifuges operate continuously at approximately 320 gpm each. For this analysis, a hydraulic processing capacity of 350 gpm was therefore selected, below the maximum capacity of 400 gpm, as shown in **Table 14-4.** For the current feed solids concentration of 0.8%, an operating solids processing capacity of 1,300 was selected.

Table 14-5 shows assumed operating schedule and projected feed HLR and SLR for future conditions. For a 24 hours per 7 days (24x7) operating schedule, the installed capacity with three units on line is sufficient to process the forecasted solids for year 2035. Therefore, a fourth new unit is proposed to provide stand-by capabilities. It would be located in the existing Thickening/Dewatering Building which appears to have been originally designed with space allocated to a future fourth thickening centrifuge.

Table 14-4 Centrifuge Thickening Facility

Number of Existing Units (Total)	3
Hydraulic Processing Capacity, each (gpm)	350
Solids Processing Capacity, each (lb/hr)	1,300
Feed Solids Concentration (% TS)	0.8%
TWAS Solids Concentration (% TS)	5.1%

Table 14-5 Centrifuge Thickening – Required No. Units

Year	2015	2025	2035
Operating Schedule (hours and days per week)	168, 7		
Operating Schedule (hours per day	24		
Max Month Feed Loading Rate			
Feed SLR (lb/hr)	2,750	2,950	3,300
Feed HLR (gpm)	690	740	830
Processing Capacity Req'd For Year 2035			
Number of Operating Units	3		
Total Solids Processing Capacity (lb/hr)	3,900		
Total Hydraulic Processing Capacity (gpm)	1,050		

Anaerobic Digestion

The existing four newer anaerobic digesters have an operating volume of 1.71 million gallons (MG), not accounting for the bottom cone. The four older digesters have an operating volume of 2.20 MG each, as summarized in **Table 14-6**.

Table 14-6 Anaerobic Digesters Facilities

Quantity	4 (Newer)	4 (Older)
Diameter (ft)	95	105
Surface Water Depth (ft) (Without Bottom Cone)	32.2	30.2
Operating Volume (MG) (Without Bottom Cone)	1.71	1.96
Total Volume (MG)	1.84	2.20

The historical feed solids concentration to the digesters is 5.1% and the effluent solids concentration is 3.1%. The monthly average volatile solids reduction (VSR) recorded by CMUD for years 2010 to 2011 is 58.7 %, a significantly high value.

The existing digesters performance for future conditions is shown in **Table 14-7** and was estimated based on the following criteria:

- SRT of 17 days at 14-day max condition. The 14-day max loading rate corresponds to the 95th percentile of the 14-day moving average load.
- VSR of 50% instead of the current 58.7%, since the destruction of volatile solids (VS) decreases with a shorter SRT. Note that assuming a VSR of 50% is conservative and may be increased during the alternatives evaluation phase as it impacts biogas generation.
- VS loading of 0.15 lb VS per cubic foot per day at 14 day max loading condition.

Table 14-7 Anaerobic Digesters Installed Capacity

Year	2015	2025	2035
14-day Peak Conditions Solids and Hydraulic Feed Loading Rate			
Feed SLR (DT/d)	87	93	105
Feed HLR (mgd)	0.40	0.43	0.48
Solids Retention Time (SRT)			
SRT (8 Digesters on-line) (d)	37	34	30
SRT (4 New + 2 Existing Digesters on-line) (d)	27	25	22
SRT (4 New + 1 Existing Digesters on-line) (d)	22	21	18

Table 14-7 shows the projected total feed HLR and SLR entering all digesters at peak conditions in year 2035. The corresponding SRT for different numbers of existing digesters in operation is also presented. The installed capacity of the existing digesters exceeds significantly the minimum required volume to maintain a desirable SRT for future solids production rates. It is estimated that only five of the existing digesters would be required to process year 2035 solids with an SRT of 17 days at 14-day peak conditions.

Centrifuge Dewatering

Table 14-8 summarizes the characteristics of the two centrifuges dewatering the solids discharged from the anaerobic digesters. One unit is typically operated 5 days per week, 24 hours per day (24x5) at approximately 320 gpm. A hydraulic processing capacity of 350 gpm, below the maximum capacity of 400 gpm, and a solids processing capacity of 5,300 lb/hr at a feed solids concentration of 3.1% were selected for this analysis. The current dewatered cake solids concentration is 18.4% is relatively low and should be optimized.

As shown in **Table 14-9**, one unit operating 24x7 is required to process year 2035 max month solids. The second unit would provide redundancy. As requested by CMUD, a third dewatering centrifuge is also proposed for installation in the existing Thickening/Dewatering Building, which appears to have space allocated for a third future dewatering unit.

Table 14-8 Centrifuge Dewatering Facility

Number of Existing Units (Total)	2
Hydraulic Processing Capacity, each (gpm)	350
Solids Processing Capacity, each (lb/hr)	5,300
Feed Solids Concentration (% TS)	3.1%
TWAS Solids Concentration (% TS)	18.4%

Table 14-9 Centrifuge Dewatering – Required No. Units

Year	2015	2025	2035
Operating Schedule (hours per week)	168		
Operating Schedule (hours per days)	24x7		
Max Month Feed Loading Rate			
Feed SLR (lb/hr)	4,100	4,370	4,950
Feed HLR (gpm)	270	285	320
Processing Capacity Req'd For Year 2035			
Number of Operating Units	1		
Total Solids Processing Capacity (lb/hr)	5,300		
Total Hydraulic Processing Capacity (gpm)	350		

Dewatered Cake Storage

Prior to land application, the dewatered solids generated at McAlpine Creek WWMF are stored at the Residuals Management Facility (RMF), which is located on site. Increase in fecal coliforms exceeding regulatory compliance limits for pathogen reduction has been an issue at this facility. Digester improvements, use of low-solids centrifuges and sludge conveyance upgrades have not eliminated fecal coliforms re-growth and the need to store the solids until pathogens are below acceptable levels. Efficient use of the space at this facility is therefore critical to address future increases in solids production, and provide storage for sufficient period of time to comply with regulatory requirements on pathogens reduction.

- *Previous Studies*: A study on the capacity improvements at this facility was conducted in 2010 and the results are presented in the 'Residuals Management Facility Capacity Improvements Study' prepared by MWH.

  According to the 2010 Study, the solids received at the RMF are currently deposited into one of five batches, which are delimited by a combination of permanent walls and movable concrete blocks. The batches are filled in sequence, and the solids are stored until pathogen levels are below compliance limits. The 2010 Study proposed layout consisted of five batches and indicated that the stacking height should not exceed four to five feet to avoid structural modifications to the floor slab and allow access during sampling along length and width of batches. In the 2010 study, a maximum stacking height of three feet was used where retaining structures existed along batches, and two feet were used elsewhere.

- *Updated RMF Evaluation*: A review of the RMF capacity was conducted based on future dewatered solids production, and the following elements were considered as part of this evaluation:

  - Ability to store dewatered cake at current solids concentration of 18% solids and for annual average loading rate projected for year 2035.
  - Use of the general layout recommended in the 2010 Study.
  - Increased batch height of five feet (instead of three feet used in the 2010 Study).
  - Increased total storage requirement to 120 days.

Considering the current layout of five batches and a batch height of five feet, the existing RMF can provide storage for approximately 11,750 wet tons. This result was obtained assuming a density of 60 lb per cubic foot (lb/cft).

The projected annual average production of dewatered cake in year 2035 is 222 wet tons per day. Using this value as design production rate and a storage requirement of 120 days, the required storage volume is 26,640 wet tons, which exceeds the existing capacity of 11,750 wet tons. Therefore, an expansion of the RMF would be required to provide sufficient storage for future solids production. It is anticipated that the new facility would be 840 feet in length by 175 feet in width and would be located adjacent to the existing facility.

14.2.3 McAlpine Creek WWMF Rehabilitation Improvements

In addition to the facility requirements identified above, an assessment of the existing facilities was performed as part of this project and is presented in Section 4. The following is a summary of the capital improvements needed for McAlpine Creek WWMF to remain in operation for the duration of the planning period.

- **New Sugar Creek WWTP Equalization Tank:** The existing WAS wet well has a capacity of 90,000 gal. According to CMUD staff it represents a bottleneck and impacts thickening operations. Currently, WAS from Sugar Creek WWTP is pumped in 30 minute batches at approximately 300 gpm over a 20 hour period each day. This flow rate is set to provide pipeline scouring velocities to maintain the force main clean from debris.

  Assuming that the current pumping schedule will be maintained in the future, one new 31,000 gal above-grade tank is proposed to receive the WAS pumped from Sugar Creek WWTP. From there, the equalized flow will be discharged to the existing wet well, where it is mixed with WAS from McAlpine Creek WWMF. At a 14-day peak condition in year 2035, it is estimated that the tank will provide two hours of storage.

- **Thickening Centrifuges**: Three centrifuges will be required to thickening the solids forecasted for year 2035 max month conditions. Therefore, a fourth centrifuge with throughput matching the existing units will be installed in the Thickening/Dewatering Building to provide stand-by capabilities. It appears that this building has allocated space for one future thickening centrifuge and one future dewatering centrifuge.
- **Dewatering Centrifuges**: It is estimated that one dewatering centrifuge will be required for the planning period if operated continuously. While a second centrifuge is currently available to provide standby capabilities, CMUD requested that a third unit be provided as it will allow increased flexibility and reliability during operations. This unit would also be installed in the Thickening/Dewatering Building.
- **RMF Expansion**: A new facility will be required to provide 120 days of storage up to year 2035. It is envisioned that this facility will measure 840 feet in length by 175 feet in width and will be located adjacent to the existing facility.
- **Phosphorus Removal**: A phosphorus removal system will be considered for all alternatives at McAlpine Creek WWMF, including Alternative 1-1 with maintenance of current operations. To avoid chemicals purchase and sludge disposal costs, in addition to taking advantage of potential revenues from fertilizer sales, nutrient management technologies have been implemented in recent years. These processes, such as Pearl by Ostara provide chemical precipitation in a fluidized bed reactor, removing the phosphorus load in the sludge dewatering liquid.

  Nutrients from the system feed streams are mixed with magnesium chloride. Sodium hydroxide is also added when needed to increase alkalinity and pH, and enhance nutrient removal. They are then fed into a fluidized bed reactor where struvite precipitates forming particles that are recovered in the form of crystalline pellets. The liquid process runs continuously. The fertilizer is removed periodically in batches and the bagged product can be potentially marketed as a commercial fertilizer.

  The quantity of orthophosphate in the feed to the phosphorus removal system at McAlpine Creek WWMF was estimated based on Ostara's experience and pilot testing at McAlpine Creek WWMF. In Ostara's experience with plants that operate biological phosphorus removal and anaerobic digestion, approximately 25% of the total mass of phosphorus entering the plant is present as orthophosphate in dewatering centrate. During pilot testing at McAlpine Creek WWMF in June 2010 an average orthophosphate concentration corresponding to 13% of the influent phosphorus mass to McAlpine Creek WWMF and Sugar Creek WWTP was measured. This is significantly less than the typical 25% ratio, possibly as a result of ferric dosing, which is routinely applied at McAlpine Creek WWMF but was temporarily discontinued when batches of centrate were collected for pilot testing. For this reason, the size of the system is based on the typical 25% mass ratio.

  For Alternative 1-1, a single reactor was proposed, with the nominal capacity to remove 555 lbs/day of orthophosphate. The system consists of the following components:

  - Building for storage of the final product.
  - Fluidized Bed Reactor.
  - Product Drying and Handling.

The total footprint of a facility employing one reactors is 3000 to 3500 square feet. The O&M cost of the phosphorus removal system is considered neutral as Ostara would distribute and market the fertilizer.

- **Mixers for Anaerobic Digesters (Not Included):** The digester mixers in the four new digesters (Digesters 5 through 8) are not operating properly. Electrical conditions suggest broken propellers and/or shafts. Removal and repair or replacement of these units is currently under way and therefore it is not included in the cost analysis. The project involves the installation of blades on three digester mixers, removal and remounting of three digester mixer gear boxes, removal of existing re-generated filter media, tank rehabilitation, and replacement of ancillary valves and components. As part of the same project, CMUD will rehabilitate the biogas scrubbers.

14.2.4 McAlpine Creek WWMF Total Life Cycle Cost

Table 14-10 provides an opinion of probable construction and O&M cost for the above facilities. In addition to direct construction costs (equipment, labor, and materials), capital cost estimates include a number of indirect costs, as illustrated in Table 9-1**.** Indirect construction costs include markups for taxes, permits, bonds, insurance, contractor's general conditions, overhead and profit, engineering services during design and construction, administrative costs, and contingency. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period. Development of costs is explained in greater detail in Section 9.

Table 14-10 Summary of Capital and O&M Costs for McAlpine Creek WWMF

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
Sugar Creek WWTP & Irwin Creek WWTP WAS EQ Tanks	$0.24	$0.31	$0.55
Existing Thickening/Dewatering Complex Upgrade	$1.71	$1.15	$2.86
Residuals Management Facility Expansion	$0.30	$7.86	$8.16
Phosphorus Removal System	$2.20	$1.06	$3.26
Subtotal Direct Construction Costs	**$4.45**	**$10.38**	**$14.83**
Subtotal Indirect Construction Costs			**$9.08**
Total Capital Cost			**$23.91**
O&M Cost			**20-Year NPV ($M)**
WAS Thickening			$22.6
Anaerobic Digestion			$7.2
Dewatering			$19.7
Land Application			$38.0
Total Net Present O&M Cost			**$87.46**
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			**$111.37**

14.3 Maintain Current Operations at Irwin Creek WWTP

14.3.1 Irwin Creek WWTP Process Description

Table 14-11 summarizes the results of the mass balance for Irwin Creek WWTP. A process flow schematic is presented in **Figure 14-2** for reference.

CDM Smith

Table 14-11 Irwin Creek WWTP Mass Balance for Year 2035 Max Month Conditions

	PS	WAS	WAS Gravity Belt Thickening Discharge	Anaerobic Digesters Feed	Anaerobic Digester Effluent	Belt Filter Press Dewatered Cake
Total SLR (dry ton/day)	11.9	8.8	8.4	20.2	12.1	11.5
TS Concentration (%)	2.7%	0.9%	5.3%	3.4%	2.0%	18.0%
Total HLR (gpd)	105,500	229,500	37,800	143,300	143,300	15,300
Total SLR (wet ton/d)	440	957	158	598	598	64

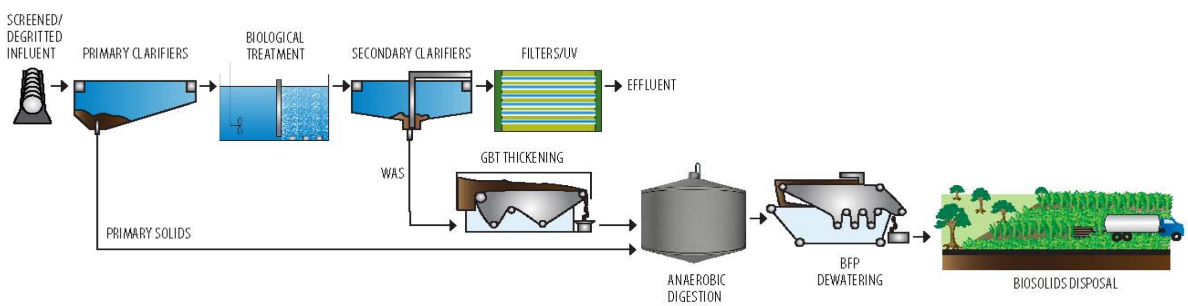

Figure 14-2
Irwin Creek WWTP Process Flow Schematic

14.3.2 Irwin Creek WWTP Existing Facilities Capacity Evaluation

WAS Gravity Belt Thickening

Table 14-12 presents the characteristics of the two GBTs used to thicken WAS fed from the final clarifiers. The maximum operating range for these units is 375 gpm, while they are currently run at 70 gpm. At the feed solids concentration of 0.9% solids and 70 gpm, the corresponding SLR is only 310 lb/hr, well below the processing capacity of these units. Therefore, for this analysis a hydraulic processing capacity of 300 gpm and a solids processing capacity of 1,125 lb/hr were selected.

Table 14-13 summarizes the feed HLR and SLR for each year of reference. One unit is sufficient to meet the projected solids loading rate up to year 2035, leaving one unit standby. This requires operating the unit on a 24x5 schedule. Therefore, no new units are required.

Table 14-12 Gravity Belt Thickening Facility

Number of Existing Units (Total)	2
Belt width	1.5-meter
Hydraulic Processing Capacity (gpm)	300
Solids Processing Capacity (lb/hr)	1,125
Feed solids concentration (% TS)	0.9%
Thickened solids concentration (% TS)	5.3%

Table 14-13 Gravity Belt Thickening – Required No. Units

Year	2015	2025	2035
Operating Schedule (hours per week)	120		
Operating Schedule (hours per days)	24x5		
Max Month Feed Loading Rate			
Feed SLR (lb/hr)	650	945	1,030
Feed HLR (gpm)	140	205	225
Processing Capacity Req'd For Year 2035			
Number of Operating Units	1		
Total Solids Processing Capacity (lb/hr)	1,125		
Total Hydraulic Processing Capacity (gpm)	300		

Anaerobic Digestion

Table 14-14 summarizes the characteristics of the four primary anaerobic digesters at the Irwin Creek WWTP, which have an operating volume of 0.50 MG each, not including the bottom cone. Two additional 0.50 MG digesters are used as secondary digesters.

Table 14-14 Anaerobic Digesters Facilities

Quantity	4 (Primary Digesters)
Diameter (ft)	65
Surface Water Depth (ft) (Without Bottom Cone)	20.25
Operating Volume (MG) (Without Bottom Cone)	0.50
Total Volume (MG)	0.56

The historical feed solids concentration to the digesters is 3.4% and the effluent solids concentration is 2.0%. The reported monthly average VSR of 67.0 % was measured by CMUD between 2010 and 2011 and is well above typical values. The performance of the existing primary digesters is presented in **Table 14-15** and was estimated based on the following criteria:

- SRT of 17 days at 14-day max condition.
- VSR of 50% instead of 67% to account for a shorter SRT.
- VS loading of 0.15 lb VS per cubic foot per day at 14 day max loading condition.

Table 14-15 Anaerobic Digesters Installed Capacity

Year	2015	2025	2035
14-day Peak Conditions Solids and Hydraulic Feed Loading Rate			
Feed SLR (DT/d)	13.3	19.4	21.1
Feed HLR (gpd)	93,950	137,000	149,200
Solids Retention Time (SRT)			
SRT (4 Digesters on-line) (d)	21	15	13
SRT (3 Digesters on-line) (d)	16	11	10
SRT (2 Digesters on-line) (d)	11	7	7

Table 14-15 shows total feed HLR and SLR entering all digesters for peak conditions. The corresponding SRT for different numbers of existing digesters in operation is also presented. The installed capacity of the existing digesters is insufficient to maintain an SRT of 17 days for year 2035 conditions. An additional primary anaerobic digester with a minimum capacity of 0.90 MG would be therefore required. As an alternative, CMUD may consider having the two secondary digesters converted to primary digesters by adding heating and mixing.

Belt Filter Press Dewatering

One portable 2-meter BFP is used to dewater the stabilized solids discharged from the anaerobic digesters, with performance characteristics as summarized in **Table 14-16.** The BFP is currently operated at a SLR between 1,100 and 1,400 lb/hr. For this analysis, solids processing capacity of 1,300 lb/hr and hydraulic processing capacity of 130 gpm at a feed solids concentration of 2.0% were selected. The historical dewatered cake solids concentration achieved with this unit is 18% solids.

The performance of the BFP is presented in **Table 14-17**, which shows that the unit is capable to dewater year 2035 solids production if run continuously, six days a week. A redundant unit is also necessary.

Table 14-16 Belt Filter Press Dewatering Facility

Number of Existing Units (Total)	1
Belt width (m)	2
Hydraulic Processing Capacity (gpm)	1,300
Solids Processing Capacity (lb/hr)	130
Feed solids concentration (% TS)	2.0%
Dewatered solids concentration (% TS)	18.0%

Table 14-17 Belt Filter Press Dewatering – Required No. Units

Year	2015	2025	2035
Operating Schedule (hours per week)	144		
Operating Schedule (hours per days, days per week)	24, 6		
Max Month Feed Loading Rate			
Feed SLR (lb/hr)	740	1,080	1,175
Feed HLR (gpm)	75	110	115
Processing Capacity Req'd For Year 2035			
Number of Operating Units	1		
Total Solids Processing Capacity (lb/hr)	1,300		
Total Hydraulic Processing Capacity (gpm)	130		

Dewatered Cake Storage

The Dewatered Cake Storage Facility located south of the plant site is approximately 470 feet long by 160 feet wide, and consists of an open-air structure with a metal roof. Digested solids produced at Irwin Creek WWTP are dewatered using the 2-meter BFP operated by Synergy at this site. Together with dewatered WTP residuals from Franklin WTP and Vest WTP, the solids can be stored on site prior to being hauled off site for land application by Synergy.

In order to assess whether the Dewatered Cake Storage Facility provides sufficient storage capacity for future solids production, the following factors were considered:

- Ability to store dewatered cake at current solids concentrations from Irwin Creek WWTP (18% solids), Franklin WTP and Vest WTP (25% solids).
- Storage requirements based on annual average loading rates projected for year 2035.
- Batch height of six feet.
- Assumed maximum storage duration of 120 days.

Assuming a density of 60 lb per cubic foot (lb/cft), the existing Dewatered Cake Storage Facility can provide storage for approximately 8,000 wet tons. The projected annual average production of dewatered cake for year 2035 is 80 wet tons per day. This amount includes 52 wet tons per day from Irwin Creek WWTP at 18% solids, and 28 wet tons per day from Franklin WTP and Vest WTP at 25% solids. Assuming a storage requirement of 120 days, the required storage volume is 9,550 wet tons, which exceeds the existing capacity of 8,000 wet tons.

Therefore, an expansion of the facility would be required to provide sufficient storage for future solids production. It is anticipated that the new facility would be 180 feet in length by 90 feet in width and would located adjacent to the existing facility. The new facility would consist of a covered concrete pad similar to the existing storage facilities. Trucks would transfer dewatered cake to the storage area, where the cake would be dumped. A front-end loader would then be used to move the cake into piles. The same equipment would be used to load trucks with residuals for transport to end use.

14.3.3 Irwin Creek WWTP Rehabilitation Improvements

In addition to the facility requirements identified above, an assessment of the existing facilities was performed as part of this project and is presented in Section 4. The following is a summary of the capital improvements needed for McAlpine Creek WWMF to remain in operation for the duration of the planning period.

- **Anaerobic Digestion System**: A new 0.9 MG anaerobic digester is required for the planning period. It will consist of a pre-stressed concrete tank with a steel cover. Additional capital improvements include two spiral heat exchangers with associated recirculation pumps, and three 7.5 hip internal draft tube mixers.

  Internal draft tube mixers employ submerged draft tubes placed inside the digester tank with the motor and belt drive mounted directly above on the digester cover. The typical pumping direction for draft tube mixers is to pull sludge from the top of the digester and pump down the draft tubes to the bottom of the digester. However, these systems are typically designed with automated controls based on timers that periodically reverse the pumping direction and pump up the draft tubes. By periodically switching the pumping direction, any top forming scum layer can be better disturbed and broken up and grit can be re-suspended.

- **Dewatered Solids Storage Facility**: A new facility will be required to provide 120 days of storage up to year 2035. This storage would receive dewatered solids from Irwin Creek WWTP as well as Vest WTP and Franklin WTP. It is envisioned that the facility will measure 180 feet in length by 90 feet in width and will be located adjacent to the existing facility. A new facility is not required if receiving solids from Irwin Creek WWTP only, as evaluated in other Alternatives.
- **Debating Facility**: A new Dewatering Facility will be constructed to house two two-meter BFPs and auxiliary equipment. It will consist of a one-story building located at the north end of the Dewatered Solids Storage Facility.

14.3.4 Irwin Creek WWTP Total Life Cycle Cost

Table 14-18 provides an opinion of probable construction and O&M cost for the above facilities. In addition to direct construction costs (equipment, labor, and materials), capital cost estimates include a number of indirect costs, as illustrated in Table 9-1**.** Indirect construction costs include markups for taxes, permits, bonds, insurance, contractor's general conditions, overhead and profit, engineering services during design and construction, administrative costs, and contingency. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period. Development of costs is explained in greater detail in Section 9.

Table 14-18 Summary of Capital and O&M Costs for Irwin Creek WWTP

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
New Dewatering Facility	$1.18	$2.53	$3.71
New Anaerobic Digester	$1.28	$2.28	$3.56
Dewatered Solids Storage Facility	$0.00	$1.69	$1.69
Subtotal Direct Construction Costs	**$2.46**	**$6.50**	**$8.97**
Subtotal Indirect Construction Costs			**$6.93**
Total Capital Cost			**$15.90**
O&M Cost			**20-Year NPV ($M)**
WAS Thickening			$3.56
An Dig			$2.30
Dewatering			$2.88
Land Application			$7.99
Total Net Present O&M Cost			**$16.72**
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			**$32.62**

14.4 Maintain Current Operations at Mallard

14.4.1 Mallard Process Description

Table 14-19 summarizes the results of the mass balance for Mallard. A process flow schematic is presented in **Figure 14-3** for reference.

Table 14-19 Mallard Mass Balance for Year 2035 Max Month Conditions

	PS	WAS Centrifuge Thickening Feed	WAS Centrifuge Thickening Effluent	Anaerobic Digesters Feed	Anaerobic Digesters Effluent	Centrifuge Dewatering Discharge
Total SLR (dry ton/day)	8.4	5.9	5.6	14.0	7.9	7.5
TS Concentration (%)	3.4%	0.7%	3.5%	3.5%	1.9%	20.0%
Total HLR (gpd)	58,600	200,700	38,100	96,800	96,800	8,900
Total SLR (wet ton/d)	245	837	159	404	404	37

14.4.2 Mallard Existing Facilities Capacity Evaluation

WAS Centrifuge Thickening

Two centrifuges are used to thicken the WAS from Process Train 1&2 and Process Train 3 secondary clarifiers. As shown in **Table 14-20**, thickening centrifuges No. 3 and No. 4 have maximum hydraulic processing capacity of 150 and 210 gpm, respectively. At the current feed solids concentration of 0.7% solids, a solids processing capacity of 500 lb/hr and 700 lb/hr was selected as solids processing capacity for centrifuges No. 3 and No.4, respectively. Note that the existing thickening performance is 3.5 percent solids, below a typical value of five percent achieved by this technology. This issue is related to poor performance of the thickened sludge pumps, which have difficulty pumping sludge thicker than 3.5 percent solids and should therefore be replaced.

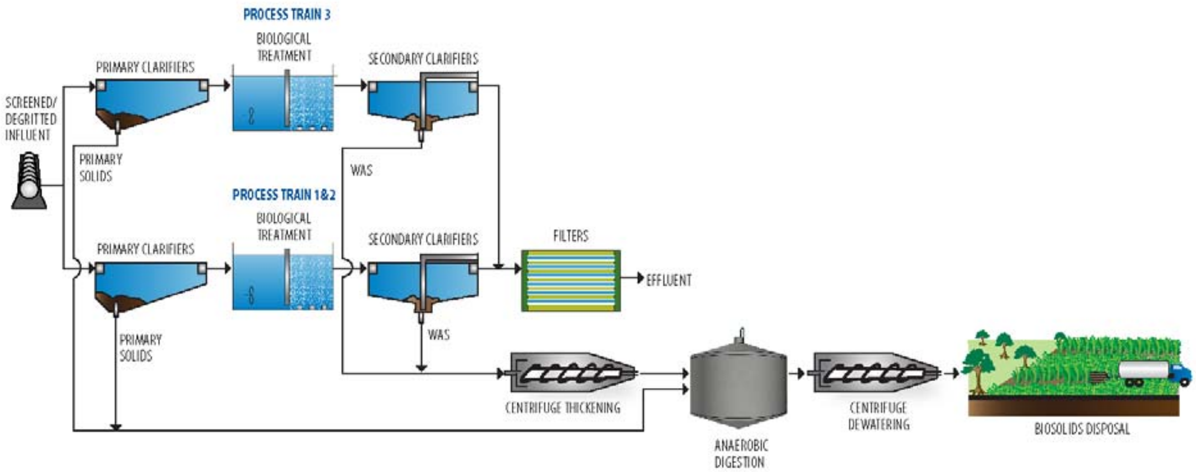

Figure 14-3
Mallard Process Flow Schematic

Table 14-20 Centrifuge Thickening Facility

Number of Existing Units	Thickening Centrifuge No.3	Thickening Centrifuge No.4
Hydraulic Processing Capacity, each (gpm)	150	210
Solids Processing Capacity, each (lb/hr)	500	700
Feed Solids Concentration (% TS)	0.7%	
TWAS Solids Concentration (% TS)	3.5%	

Table 14-21 shows assumed operating schedule and projected hydraulic and loading rates for future conditions. For a 24x7 operating schedule, the installed capacity provided by the single smaller unit is just sufficient to process the solids forecasted for year 2035. The second larger centrifuge would provide redundancy. Therefore, given the uncertainty in future solids production rates, it is proposed to replace the smaller thickening centrifuge with a larger unit, comparable in size to or larger than Thickening Centrifuge No. 4. It is anticipated that the new centrifuge could fit in the existing building.

Table 14-21 Centrifuge Thickening – Required No. Units

Year	2015	2025	2035
Operating Schedule (hours per week)	168		
Operating Schedule (hours per days)	7x24		
Max Month Feed Loading Rate			
Feed SLR (lb/hr)	345	410	490
Feed HLR (gpm)	115	135	140
Processing Capacity Req'd For Year 2035			
Number of Operating Units	1		
Total Solids Processing Capacity (lb/hr)	500		
Total Hydraulic Processing Capacity (gpm)	150		

Anaerobic Digestion

There are three original primary anaerobic digesters with a capacity of 0.48 MG each dedicated to Process Train 1&2 and one newer primary digester dedicated to Process Train 3 with a capacity of 1.15 MG, for a total operating volume of 2.58 MG, as summarized in **Table 14-22**. One secondary digester with a capacity of 0.48 MG is also available.

Table 14-22 Anaerobic Digesters Facilities

Quantity	3 (Primary Digesters)	1 (Primary Digesters)
Diameter (ft)	55	85
Surface Water Depth (ft)	27	27
Operating Volume (MG) (Without Bottom Cone)	0.48	1.14
Volume, total (MG)	2.58	

The historical feed solids concentration to the digesters is 3.5% and the effluent solids concentration is 1.9%. A significant monthly average VSR of 61% was observed by CMUD between 2010 and 2011. The performance of the existing primary digesters is shown in **Table 14-23** and was estimated using the following criteria:

- SRT of 17 days at 14-day max condition.
- VSR of 50% instead of the current 61% for the shorter SRT used for this analysis. Note that this value is conservative and may be increased during the alternatives evaluation phase as it impacts biogas generation.
- VS loading of 0.15 lb VS per cubic foot per day at 14 day max loading condition.

Table 14-23 Anaerobic Digesters Installed Capacity

Year	2015		2025		2035	
Process Train	Train 1&2	Train 3	Train 1&2	Train 3	Train 1&2	Train 3
14-day Peak Conditions Solids and Hydraulic Feed Loading Rate						
Feed SLR (DT/d)	5.6	4.4	6.7	5.2	7.9	6.2
Feed HLR (gpd)	38,600	30,150	46,100	36,000	55,000	43,000
SRT (all digesters on-line) (d)	37	38	31	32	26	27
SRT (two 0.48-MG digesters + one 1.15-MG digester on line) (d)	25	38	21	32	17	27
SRT (one 0.48-MG digesters + one 1.15-MG digester on line) (d)	12	38	10	32	9	27

Table 14-23 summarizes the results at 14-day peak loading conditions for the existing digesters. For each year of reference, the SRT corresponding to each loading rate is also shown. The operating volume with all digesters on line is greater than the minimum 17 days required at 14-day peak conditions.

This condition is met by operating two of the three 0.48 MG digesters coupled with the newer 1.15 MG digester. No new units are therefore required.

Centrifuge Dewatering

Two centrifuges with different performance characteristics are used to dewater the stabilized solids from the anaerobic digesters, as summarized in **Table 14-24**. The maximum hydraulic processing capacity of Dewatering Centrifuge No. 1 and No. 2 is 75 gpm and 200 gpm, respectively. One unit is typically operated 24x7. For this analysis, the selected hydraulic processing capacity of Dewatering Centrifuge No. 1 and No. 2 is 70 gpm and 150 gpm respectively, with a solids processing capacity of 700 and 1,450 lb/hr at a feed solids concentration of 1.9%.

Table 14-24 Centrifuge Dewatering Facility

Number of Existing Units	Dewatering Centrifuge No. 1	Dewatering Centrifuge No. 2
Hydraulic Processing Capacity, each (gpm)	70	150
Solids Processing Capacity, each (lb/hr)	700	1,450
Feed Solids Concentration (% TS)	1.9%	
Dewatered Cake Solids Concentration (% TS)	20%	

As shown in **Table 14-25**, the smaller unit is capable to dewater year 2035 max month solids production if running continuously. However, in order to provide additional flexibility during operations, it is proposed that the smaller dewatering be replaced at the same location with a larger unit, similar in size or exceeding the capacity of Dewatering Centrifuge No. 2.

Table 14-25 Centrifuge Dewatering – Required No. Units

Year	2015	2025	2035
Operating Schedule (hours per week)	168.0		
Operating Schedule (hours per days)	24x7		
Max Month Feed Loading Rate			
Feed SLR (lb/hr)	460	550	655
Feed HLR (gpm)	45	55	67
Processing Capacity Req'd For Year 2035			
No. Units Operating Simultaneously	1		
Installed Processing SLR (lb/hr)	700		
Installed Processing HLR (gpm)	70		
Number of Operating Units Req'd to Process Year 2035 Solids Production	1 (with smaller unit)		

Dewatered Cake Storage

The Dewatered Cake Storage Facility at the plant site is approximately 210 feet long by 65 feet wide, and consists of an open-air structure with a metal roof. Digested solids from the plant dewatering centrifuges can be stored at this site prior to being hauled off site for land application by Synagro. In order to assess whether the Dewatered Cake Storage Facility provides sufficient storage capacity for future solids production, the following factors were considered:

- Ability to store dewatered cake at current solids concentrations from Mallard (20% solids).
- Storage requirements based on annual average loading rates projected for year 2035.

- Batch height of six feet.
- Assumed maximum storage duration of 110 days.

Assuming a density of 60 lb/cft, the existing Dewatered Cake Storage Facility can provide storage for approximately 3,400 wet tons. The projected annual average production of dewatered cake for year 2035 is 31wet tons per day at a dewatered solids concentration of 20%. This capacity is sufficient to provide storage for approximately 110 days, which is deemed acceptable, although slightly inferior to the 120 days used for other facilities.

Therefore, an expansion of the facility would not be required.

14.4.3 Mallard Rehabilitation Improvements

In addition to the facility requirements identified above, an assessment of the existing facilities was performed as part of this project and is presented in Section 4. The following is a summary of the capital improvements needed for Mallard Creek WRF to remain in operation for the duration of the planning period.

- **Thickened/Dewatering Facilities Upgrade**: The diaphragm pumps used to discharge thickened WAS to the digesters require significant maintenance for operation and are prone to clogging. Further, pumping solids above four percent requires dilution of the sludge. CMUD staff would like to replace these units with pumps that are suitable for high solids concentrations and are less maintenance intensive, such as progressing cavity pumps. The opinion of probable construction cost includes the replacement of the existing diaphragm pumps with 100 gpm progressing cavity pumps.

  Mallard Creek WRF is currently equipped with two thickening centrifuges having different performance from each other. In order to process future solids projections, the smaller unit will be replaced with a larger thickening centrifuge with a capacity of 700 lb/hr at 0.7 percent solids. Similarly, the smaller dewatering centrifuge would be replaced with a larger unit with a capacity of 2,000 lb/hr at 1.9 percent solids. The need for additional dewatering capacity was identified by CMUD staff. This improvement would allow operating a single thickening and dewatering unit for the entire planning period, leaving the other unit on standby. It is anticipated that the two larger centrifuges could fit in the existing building, based on preliminary information from equipment manufacturers. However, given the limited space available, this will need to be confirmed during design. While the proposed new thickening centrifuge has dimensions similar to the existing larger unit, the new proposed dewatering centrifuge is substantially larger, making this installation tight in the current space allocated for these units.

- **Biogas Conditioning System**: Mallard Creek WRF is the only facility operated by CMUD that is not equipped with a biogas scrubbing system, which has led to corrosion issues in the gas handling system. The biogas conditioning system includes the following components:

  - **Sulfur Removal**: Hydrogen sulfide and organic sulfur removal from biogas is often necessary to prevent corrosion or the increased maintenance of downstream equipment. The method envisioned for this application is an iron sponge system, consisting of a 6 feet diameter x 10 feet high steel vessels packed with removal media. Biogas enters the top of the vessel, flows through the removal media and exits the bottom of the vessel via an outlet pipe. Over time, as the media is spent, the outlet concentration gradually increases until the media must be replaced.

- **Gas Compression/Moisture**: This system is equipped with a gas blower and a dual core heat exchanger to remove moisture, large particulate and liquid droplets. The dual core heat exchangers functions as two heat exchangers, the first of which uses hot gas from compression to reheat the cold gas from the second heat exchanger. A glycol chiller is used to cool the gas to 40 °F.

14.4.4 Mallard Creek WRF Total Life Cycle Cost

Table 14-26 provides an opinion of probable construction and O&M cost for the above facilities. In addition to direct construction costs (equipment, labor, and materials), capital cost estimates include a number of indirect costs, as illustrated in Table 9-1**.** Indirect construction costs include markups for taxes, permits, bonds, insurance, contractor's general conditions, overhead and profit, engineering services during design and construction, administrative costs, and contingency. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period. Development of costs is explained in greater detail in Section 9.

Table 14-26 Summary of Capital and O&M Costs for Mallard Creek WRF

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
Biogas Conditioning System	$0.41	$0.32	$0.73
Thickened WAS Pumps Replacement	$1.47	$0.60	$2.07
Subtotal Direct Construction Costs	**$1.88**	**$0.92**	**$2.80**
Subtotal Indirect Construction Costs			**$2.33**
Total Capital Cost			**$5.13**
O&M Cost			**20-Year NPV ($M)**
WAS Thickening			$7.09
An Dig			$1.14
Dewatering			$6.07
Land Application			$4.86
Total Net Present O&M Cost			**$19.17**
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			**$24.30**

14.5 Maintain Current Operations at McDowell WRF

14.5.1 McDowell WRF Process Description

Table 14-27 summarizes the results of the mass balance for McDowell WRF. A process flow schematic is presented in **Figure 14-4** for reference.

Table 14-27 McDowell WRF Mass Balancer for Year 2035 Max Month Conditions

	PS	WAS	WAS Gravity Belt Thickening Effluent	Anaerobic Digesters Feed	Anaerobic Digestion Effluent	Belt Filter Press Dewatered Cake
Total SLR (dry ton/day)	5.4	4.9	4.6	10.0	5.9	5.6
TS Concentration (%)	3.4%	0.7%	4.0%	3.7%	2.2%	13.0%
Total HLR (gpd)	37,800	167,500	27,900	65,700	65,700	10,400
Total SLR (wet ton/d)	160	700	120	280	280	43

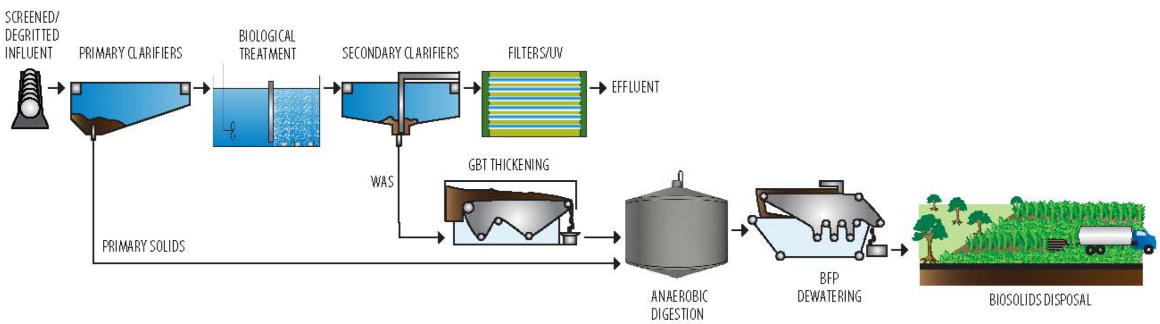

Figure 14-4
McDowell Process Flow Schematic

14.5.2 McDowell WRF Existing Facilities Capacity Evaluation

WAS Gravity Belt Thickening

Two 1.5 meter GBTs are used to thicken WAS from the final clarifiers. Currently the typical hydraulic operating range varies between 75 and 120 gpm. This rate is well below the typical capacity for GBTs fed at low solids concentrations. According to MOP 8 (Table 23.13), a 1.5 meter GBT can process between 150 and 375 gpm. As summarized in **Table 14-28**, a hydraulic processing capacity of 300 gpm was therefore selected, higher than currently used. The solids processing capacity used for this analysis was 1,125 lb/hr at a feed solids concentration of 0.7%. Note that the thickening concentration achieved by the GBTs is 4% solids, lower than typical values of 5% achieved by this technology.

Table 14-29 summarizes the solids production for each year of reference, and the required run time to process the solids. One unit is sufficient to meet the projected solids loading rate up to year 2035, leaving one unit standby. This requires operating the unit 80 hours per week (e.g., 16X5).

Therefore, no new GBTs are required for the planning period.

Table 14-28 Gravity Belt Thickening Facility

Number of Existing Units (Total)	2
Belt width	1.5-meter
Hydraulic Processing Capacity (gpm)	300
Solids Processing Capacity (lb/hr)	1,125
Feed solids concentration (% TS)	0.7%
Thickened solids concentration (% TS)	4.0%

Table 14-29 Gravity Belt Thickening – Required No. Units

Year	2015	2025	2035
Operating Schedule (hours per week)	80		
Operating Schedule (hours, days)	16, 5		
Max Month Feed Loading Rate			
Feed SLR (lb/hr)	700	770	860
Feed HLR (gpm)	200	220	245
Processing Capacity Req'd For Year 2035			
Number of Operating Units	1		
Total Solids Processing Capacity (lb/hr)	1,125		
Total Hydraulic Processing Capacity (gpm)	300		

Anaerobic Digestion

There are three original primary anaerobic digesters with a capacity of 0.48 MG each and one newer primary digester for Process Train 3 with a capacity of 1.46 MG, for a total operating volume of 2.90 MG, as summarized in **Table 14-30**. The older units are in poor condition are not typically used. For gas storage, a secondary 0.48 MG digester is also provided.

Table 14-30 Anaerobic Digesters Facilities

Quantity	3 (Primary Digesters)	1 (Primary Digesters)
Diameter (ft)	55	90
Surface Water Depth (ft)	27	30.6
Operating Volume (MG) (Without Bottom Cone)	0.48	1.46
Volume, total (MG)	2.90	
Feed Solids Concentration (% TS)	3.7%	
Effluent Solids Concentration (% TS)	2.2%	

The historical feed solids concentration to the digesters is 3.7% and the effluent solids concentration is 2.2%. The monthly average VSR of 50.0 % was observed between 2010 and 2011. The required capacity was estimated as the maximum volume calculated using the following criteria:

- SRT of 17 days at 14-day max condition and VSR of 50%.
- VS loading of 0.15 lb VS per cubic foot per day at 14 day max loading condition.

Table 14-31 summarizes the results at 14-day peak loading conditions for the existing digesters. For each year of reference, the SRT corresponding to each loading rate is also shown. The operating volume with the 1.43 MG primary digester is sufficient to process the feed HLR forecasted for year 2035 with an SRT of 21 days, which is greater than the minimum 17 days required at 14-day peak conditions. Therefore, no additional digesters are required.

Table 14-31 Anaerobic Digesters Installed Capacity

Year	2015	2025	2035
14-day Peak Conditions Solids and Hydraulic Feed Loading Rate			
Feed SLR (DT/d)	8.5	9.4	10.5
Feed HLR (gpd)	56,000	61,900	68,900
Solids Retention Time (SRT)			
SRT (three 0.48-MG digesters + 1.43-MG digester on line) (d)	52	47	42
SRT (two 0.48-MG digesters + 1.43-MG digester on line) (d)	43	39	35
SRT (one 0.48-MG digesters + 1.43-MG digester on line) (d)	35	31	28
SRT (one 1.43-MG digester on line) (d)	26	24	21

Belt Filter Press Dewatering

Two 2-meter BFPs are used to dewater the stabilized solids from the anaerobic digesters, with performance characteristics as summarized in **Table 14-32**. These units currently operate at an average of 170 gpm (ranging between 120 and 180 gpm). A hydraulic processing capacity of 130 gpm and a solids processing capacity of 1,300 lb/hr at a feed solids concentration of 2.0% were conservatively selected for this analysis.

The performance of the BFPs is evaluated in **Table 14-33.** It is estimated that one unit running 80 hours per week (e.g., 24x5) is required to process max month loadings in year 2035, with the other unit on stand-by. Therefore, no new BFPs are required for the planning period.

Table 14-32 Belt Filter Press Dewatering Facilities

Number of Existing Units (Total)	2
Belt width (m)	2
Hydraulic Processing Capacity (gpm)	130
Solids Processing Capacity (lb/hr)	1,300
Feed solids concentration (% TS)	2.1%
Dewatered solids concentration (% TS)	13%

Table 14-33 Belt Filter Press Dewatering – Required No. Units

Year	2015	2025	2035
Operating Schedule (hours per week)	80		
Operating Schedule (hours per days)	16x5		
Max Month Feed Loading Rate			
Feed SLR (lb/hr)	845	930	1,040
Feed HLR (gpm)	80	85	100
Processing Capacity Req'd For Year 2035			
Number of Operating Units	1		
Total Solids Processing Capacity (lb/hr)	1,300		
Total Hydraulic Processing Capacity (gpm)	130		

Dewatered Cake Storage

The Dewatered Cake Storage Facility at the plant site is approximately 100 feet long by 60 feet wide, and consists of an open-air structure with a metal roof. Digested solids from the plant dewatering BFPs can be stored on site prior to being hauled off site for land application by Synagro. In order to assess whether the Dewatered Cake Storage Facility provides sufficient storage capacity for future solids production, the following factors were considered:

- Ability to store dewatered cake at a solids concentration of 16%, greater than the current 13%. This assumption implies that the existing issues with dewatering operations will be addressed in the future.
- Storage requirements based on annual average loading rates projected for year 2035.
- Batch height of five feet.
- Assumed maximum storage duration of 120 days.

Assuming a density of 60 lb/cft, the existing Dewatered Cake Storage Facility can provide storage for, approximately 520 wet tons. The projected annual average production of dewatered cake for year 2035 is 29 wet tons per day at a solids concentration of 16% (greater than the current 13% solids cake). Assuming a storage requirement of 120 days, the total storage volume is 3,450 wet tons, which exceeds the existing capacity of 520 wet tons.

Therefore, an expansion of the facility would be required to provide sufficient storage for future solids production. It is anticipated that the new facility would be 300 feet in length by 130 feet in width and would be located north of the existing facility. The new facility would consist of a covered concrete pad similar to the existing storage facilities. Trucks would transfer dewatered cake to the storage area, where the cake would be dumped. A front-end loader would then be used to move the cake into piles. The same equipment would be used to load trucks with residuals for transport to end use.

14.5.3 McDowell WRF Rehabilitation Improvements

The following is a summary of the capital improvements needed for McAlpine Creek WWMF to remain in operation for the duration of the planning period.

- **Dewatered Residuals Cake Storage Facility**: A new facility will be required to provide 120 days of storage up to year 2035. It will measure 300 feet in length by 130 feet in width and will be located adjacent to the existing facility.

14.5.4 McDowell WRF Total Life Cycle Cost

Table 14-34 provides an opinion of probable construction and O&M cost for the above facilities. In addition to direct construction costs (equipment, labor, and materials), capital cost estimates include a number of indirect costs, as illustrated in Table 9-1**.** Indirect construction costs include markups for taxes, permits, bonds, insurance, contractor's general conditions, overhead and profit, engineering services during design and construction, administrative costs, and contingency. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period. Development of costs is explained in greater detail in Section 9.

Table 14-34 Summary of Capital and O&M Costs for McDowell WRF

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
Dewatered Residuals Storage Facility	$0.00	$3.67	$3.67
Subtotal Direct Construction Costs	$0.00	$3.67	$3.67
Subtotal Indirect Construction Costs			$2.27
Total Capital Cost			$5.94
O&M Cost			**20-Year NPV ($M)**
WAS Thickening			$2.54
Anaerobic Digestion			$0.53
Dewatering			$2.29
Land Application			$4.82
Total Net Present O&M Cost			$10.18
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			**$16.12**

14.6 Total Life Cycle Cost for Alternative 1-1: Maintain Current Operations

A comprehensive life cycle of the capital improvements and O&M costs required at all WWTPs to maintain current operations for the planning period is summarized in **Table 14-35**.

Table 14-35 Summary of Capital and O&M Costs for Alternative 1-1

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
McAlpine Creek WWMF Direct Construction Costs	$4.45	$10.38	$14.83
Irwin Creek WWTP Direct Construction Costs	$2.46	$6.50	$8.97
Mallard Creek WRF Direct Construction Costs	$1.88	$0.92	$2.80
McDowell WRF Direct Construction Costs	$0.00	$3.67	$3.67
Subtotal Direct Construction Costs	$8.79	$21.47	$30.27
Subtotal Indirect Construction Costs			$20.61
Total Capital Cost			**$50.88**
O&M Cost			**20-Year NPV ($M)**
WAS Thickening			$35.80
Anaerobic Digestion			$11.19
Dewatering			$30.90
Land Application			$55.65
Total Net Present O&M Cost			**$133.54**
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			**$184.42**

14.6.1 Alternative 1-1 Greenhouse Gas Emissions Offset

The lifecycle greenhouse gas (GHG) emissions associated with this alternative are presented in **Table 14-36**. Section 9.3.3 presents background information regarding greenhouses gas emissions and the model that was used to prepare the GHG emissions offset values.

Table 14-36 Greenhouse Gas Emissions for Alternative 1-1

Wastewater Treatment Facility	Metric Tons CO2 Equivalents per Year
McAlpine Creek WWMF	4,200
Irwin Creek WWTP	(900)
Mallard Creek WRF	700
McDowell WRF	(350)
Total	**3,650**

Section 15

WWTP Pre-Treatment Alternatives Evaluation

15.1 Overview of Pre-Treatment Alternatives

This section evaluates the pre-treatment alternatives summarized in **Table 15-1**.

Table 15-1 Pre-Treatment Alternatives for WWTP Biosolids Management

<table>
<tr><th>WWTP</th><th>Alternative 3-4</th><th>Alternative 3-6</th><th>Alternative 3-7</th><th>Alternative 3-8</th></tr>
<tr><td>McAlpine Creek WWMF</td><td>Add thermal hydrolysis upstream of anaerobic digestion</td><td>Add thermal hydrolysis upstream of anaerobic digestion</td><td rowspan="4">Add electrical lysis process of anaerobic digestion</td><td>Add thermal hydrolysis upstream of anaerobic digestion</td></tr>
<tr><td>Irwin Creek WWTP</td><td rowspan="3">Maintain anaerobic digestion</td><td>Pump liquid sludge from Irwin Creek WWTP to McAlpine Creek WWMF for treatment</td><td rowspan="3">Add electrical lysis upstream of anaerobic digestion</td></tr>
<tr><td>Mallard</td><td rowspan="2">Maintain anaerobic digestion</td></tr>
<tr><td>McDowell Creek WRF</td></tr>
</table>

These alternatives were identified from a preliminary screening process presented in Section 8, in which they were derived from the combination of management strategies at each WWTP. A detailed evaluation is presented for each alternative in the following, including design characteristics, non-monetary factors, and a life cycle cost analysis based on conceptual construction and annual O&M costs (**Appendix D**). This evaluation assumes that construction will be completed in year 2016. O&M costs are projected for the 20-year period between 2016 and 2035. The methodology for this analysis is further discussed in Section 9.

The following considerations apply to the alternatives in Table 15-1.

- **McAlpine Creek WWMF (Alternatives 3-4, 3-6 & 3-8)**

  Thermal Hydrolysis Process with Anaerobic Digestion **-** Prior to anaerobic digestion, sludge is fed through a thermal hydrolysis process (THP) in which the reactors are heated with steam to 320 °F and pressurized to 100 psi, achieving pathogen reduction and biomass cell lysis. Following hydrolysis, sludge is diluted with effluent water and is fed to anaerobic digesters. THP offers several benefits:

  - Increased digester solids loading at 10 to 11 percent solids.
  - Higher VSR, estimated at 60 percent, resulting in fewer residual solids and greater biogas production.
  - Improved dewatering performance with drier cake at 30 percent solids.
  - Class A product, no fecal regrowth issues.

- Essentially an odorless product.

While this technology is becoming increasingly established, with approximately 20 installations worldwide and the world largest facility being constructed at the DC Water Blue Plains facility, it requires additional processes:

- Pre-screening of the co-settled primary solids and WAS, prior to pre-dewatering.
- Pre-dewatering to produce dewatered cake with 17 percent solids discharged directly into solids cake bins prior to THP.

- **Irwin Creek WWTP (Alternative 3-4), Mallard Creek WRF & McDowell Creek WRF (Alternatives 3-4 & 3-6)**

  Anaerobic Digestion – This management strategy is characterized by maintaining current operations with mesophilic anaerobic digestion. Primary solids (PS) (thickened or not, depending on the existing set up at each facility) and thickened WAS are sent to the digesters, which are maintained at a temperature of approximately 95 °F, assuming a minimum SRT of 17 days at two week max solids loading rates. It is possible that in the future digestion will experience a reduction in VS, due to increased solids loadings. While VSR values up to 60 percent have been measured in the past, it has been assumed that the future VSR could decrease to 50 percent.

- **Irwin Creek WWTP (Alternative 3-6)**

  Sludge Transfer to McAlpine Creek WWMF – Unthickened PS and WAS at a solids concentration of less than 1 percent will be pumped to McAlpine Creek WWMF for processing and handling. Two new pump stations dedicated to each solids stream will be established at Irwin Creek WWTP, and will convey the liquid unstabilized sludge to McAlpine Creek WWMF through separate force mains. The existing facilities at Irwin Creek WWTP will be phased out.

- **McAlpine Creek WWMF (Alternative 3-7), Irwin Creek WWTP, Mallard Creek WRF & McDowell Creek WRF (Alternatives 3-7 & 3-8)**

  Electrical Lysis Process with Anaerobic Digestion – High frequency electronic pulses are applied to the WAS stream, rupturing cell membranes and releasing soluble material that can improve VSR and biogas generation. Once treated, the WAS is discharged to the digesters where VSR of the WAS portion can exceed 70 percent.

15.2 Alternative 3-4: McAlpine Creek WWMF Thermal Hydrolysis

Alternative 3-4 couples anaerobic digestion and thermal hydrolysis at McAlpine Creek WWMF with no change in current operations at the other WWTPs.

15.2.1 McAlpine Creek WWMF Process Description

A process flow schematic and a site layout for Alternative 3-4 at McAlpine Creek WWMF are presented in **Figure 15-1** and **Figure 15-2**. **Table 15-2** summarizes the results of the mass balance.

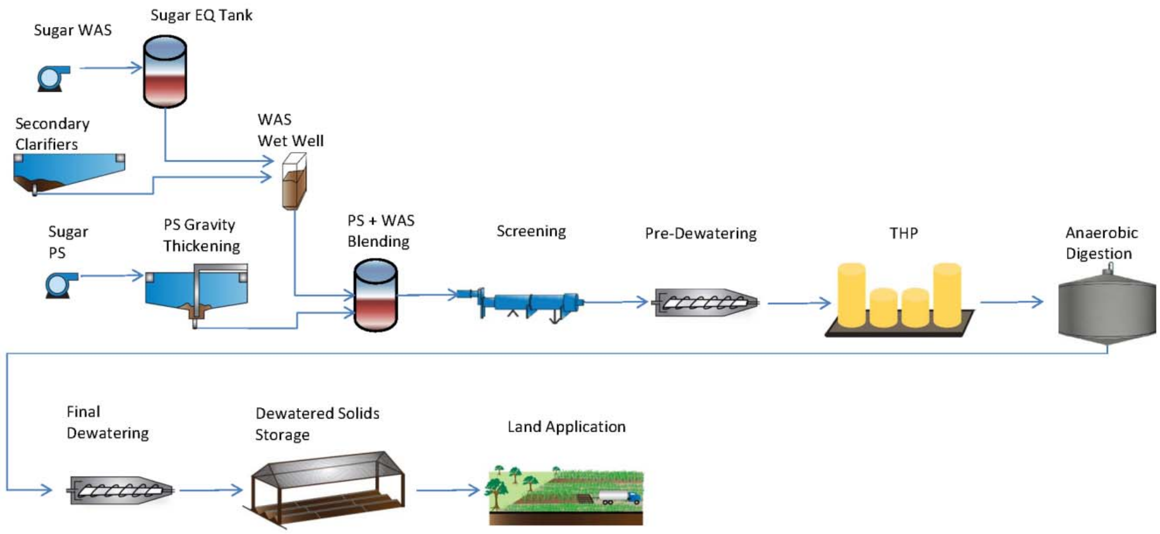

Figure 15-1
Alternative 3-4 McAlpine Creek WWMF Process Flow Schematic

WAS and PS will blend in a common tank prior to screening and pre-dewatering. These processes precede thermal hydrolysis and are required to remove coarse material that could damage the reactors and achieve a sufficiently high feed solids concentration (17 to 25 percent, depending on the supplier) before hydrolysis. The hydrolyzed sludge is then cooled from approximately 194 degrees Fahrenheit to 95 degrees Fahrenheit prior to feeding mesophilic digesters. The stabilized biosolids are then dewatered and disposed of.

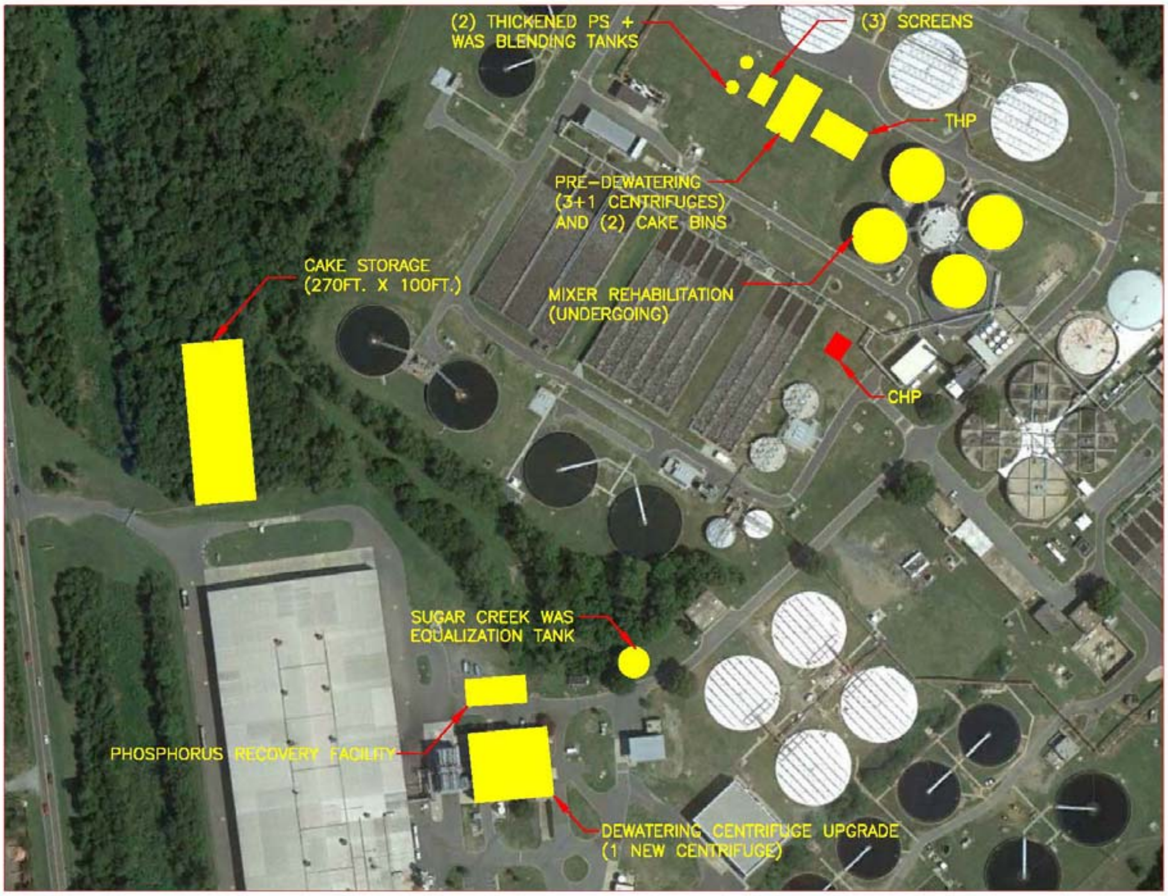

Figure 15-2
Alternative 3-4 McAlpine Creek WWMF Site Layout

Table 15-2 Alternative 3-4 McAlpine Creek WWMF Mass Balance for Year 2035 Max Month Conditions

Unit Process	PS	PS Gravity Thickening Discharge	WAS	THP Pre-Dewatering Feed	THP Pre-Dewatering Effluent	THP Effluent	Anaerobic Digestion Effluent	Centrifuge Dewatered Cake
Total SLR (dry ton/day)	66.2	62.9	39.8	102.6	97.5	97.5	49.4	46.9
TS Concentration (%)	0.2%	5.3%	0.8%	1.6%	17.0%	11.0%	5.6%	30.0%
Total HLR (gpd)	6,815,000	285,000	1,198,000	1,511,000	138,000	213,000	213,000	38,000
Total SLR (wet ton/d)	28,420	1,190	5,000	6,300	580	890	890	160

15.2.2 McAlpine Creek WWMF Facilities Required

Sugar Creek WWTP WAS Equalization Tank

New Equalization Tank for WAS stream from Sugar Creek WWTP, located upstream of existing WAS wet well, as discussed in Section 14 for Alternative 1-1.

PS and WAS Blending

Thickened PS from the existing gravity thickeners and WAS will be discharged to two new 35,000 gal above-grade blending tanks, fed continuously in parallel prior to discharge to the pre-screening facility. The purpose of these tanks is limited to blending the two liquid streams, and they are not sized to provide any retention time. Each tank will be equipped with a mixer to maintain the solids in suspension.

Pre-Screening

Three horizontal in-line coarse solids screens with a maximum capacity of 450 gpm each at 1.3% solids will be installed on an elevated platform. These units remove grit and large solids from the blended sludge. The units will be located on the second floor inside a building equipped with an odor control system. A dumpster will be provided below the screens to collect the compacted coarse material.

Pre-Dewatering

The pre-dewatering equipment will be located in a new Pre-Dewatering Building with three levels to pre-dewater the solids feeding the THP system to approximately 17% solids. Three centrifuges operating 24x7 will be required under year 2035 max month conditions. It is assumed that the existing thickening centrifuges will be relocated to this new building for this purpose. A new centrifuge will be also installed to provide stand-by capacity.

Table 15-3 summarizes the design criteria for this equipment. The dewatered cake from the centrifuges will be equalized in two cake bins. Each bin will have a storage capacity of 6,500 cft and will be equipped with live bottom screws, chutes and slide gates.

Table 15-3 Pre-Dewatering Centrifuges

Parameter	Design Criteria
Number of Units (Including 1 Stand-by Unit)	4
Solids Processing Capacity	3,200 dry lb/hr
Hydraulic Processing Capacity	400 gpm
Feed Solids Concentration	1.6 %
Outlet Solids Concentration	17 %
Solids Capture Efficiency	95 %

The pre-dewatering centrifuges will be located in the building's top level, discharging directly to cake bins located below. The second level will house the polymer day tanks and polymer feed pumps as well as the control and electrical room and cake bins. The first level will contain the pre-dewatering centrifuge feed pumps, the pre-dewatered cake bin discharge conveyors and pre-dewatering THP feed pumps.

Thermal Hydrolysis Process

Pre-dewatered cake is fed to the THP from the centrifuges/cake bins/cake pumps installed in the Pre-Dewatering Building. Proposals from the two currently available suppliers, Cambi and Veolia, were evaluated. The TPH system will be installed on a concrete pad outdoors, and will be provided as a pre-packaged, pre-engineered system by the vendor.

While the considerations below apply to the Cambi system, Veolia's Exelys-LD system is also deemed a viable option for further consideration, should THP be selected for implementation. The THP equipment proposed by Cambi consists of two process trains. Each train is comprised of the following items: a pulper, three reactors and associated feed pumps, a flash tank where steam is recovered, and digester feed pumps to convey treated sludge into the anaerobic digesters.

Anaerobic Digesters

Digester Tanks

It is estimated that three of the existing, newer digesters will be sufficient to process the hydrolyzed sludge from the THP with a VSR of 60 percent. A forth digester will be maintained as secondary digester and gas holding tank.

This analysis assumes that the existing mixers, recently rehabilitated, will be maintained. An alternative would be to replace them, either in kind or with other mixing technologies, such as internal draft tube mixers. It is estimated that four 15 hp mixers would be required for each tank. Internal draft tube mixers employ submerged draft tubes placed inside the digester tank with the motor and belt drive mounted directly above on the digester cover. The typical pumping direction for draft tube mixers is to pull sludge from the top of the digester and pump down the draft tubes to the bottom of the digester. However, these systems are typically designed with automated controls based on timers that periodically reverse the pumping direction and pump up the draft tubes. By periodically switching the pumping direction, any top forming scum layer can be better disturbed and broken up and grit can be re-suspended.

Digester Auxiliary Equipment

A portion of the digesting sludge will be recirculated and mixed with hydrolyzed undigested sludge in cooling heat exchangers to reduce the temperature from approximately 194 F to 95 F. There will be two concentric-tube heat exchangers configured in parallel per digester.

Final Dewatering

The two existing dewatering centrifuges located in the Thickening/Dewatering Building will continue to dewater the stabilized solids from the digesters. It is estimated that one unit operating 24x7 will be required under year 2035 max month conditions. Similarly to Alternative 1-1, one additional dewatering centrifuge, as requested by CMUD, will be provided with characteristics similar to the existing units and shown in **Table 15-4**. It is envisioned that no modifications to the existing screw conveyance system would be required.

Table 15-4 Final Dewatering Centrifuges

Parameter	Design Criteria
Number of Units (Including 1 Stand-by Unit)	2
Solids Processing Capacity	9,700 dry lb/hr
Hydraulic Processing Capacity	350 gpm
Feed Solids Concentration	5.5 %
Outlet Solids Concentration	30 %
Solids Capture Efficiency	95 %

Dewatered Cake Storage

Prior to land application, the dewatered solids generated at McAlpine Creek WWMF are stored at the RMF on site. The projected annual average production of dewatered cake in year 2035 is 114 wet tons per day. For a storage requirement of 120 days, the total storage volume is 13,700 wet tons, which exceeds the existing capacity of 11,750 wet tons. Therefore, an expansion of the RMF would be required to provide sufficient storage for future solids production. It is anticipated that the new facility would be 270 feet in length by 100 feet in width and would be located adjacent to the existing facility.

End Use of Biosolids

Land application would remain the disposal outlet for the biosolids. However, the final product would be a Class A material associated to a significant reduction in volume.

Phosphorus Removal

The phosphorus removal system for this alternative will be larger than for current operations, as thermal hydrolysis generates more phosphorus than digestion alone. Ostara estimated that two Pearl 2000 reactors will be required, with a storage building of 3500 to 4250 sft.

15.2.3 Alternative 3-4 Irwin Creek WWTP, Mallard Creek WRF & McDowell Creek WRF

Process Description, Facilities Required and Total Present Worth

Under Alternative 3-4, Irwin Creek WWTP, Mallard Creek WRF and McDowell Creek WRF will not change their current operations. Therefore, the conclusions and life cycle results presented in Section 14 apply to these WWTPs.

15.2.4 Alternative 3-4 (McAlpine Creek WWMF Thermal Hydrolysis) Total Life Cycle Cost

Table 15-5 provides an opinion of probable construction and O&M cost for Alternative 3-4. In addition to direct construction costs (equipment, labor, and materials), capital cost estimates include a number of indirect costs, as illustrated in Table 9-1**.** Indirect construction costs include markups for taxes, permits, bonds, insurance, contractor's general conditions, overhead and profit, engineering services during design and construction, administrative costs, and contingency. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period. Development of costs is explained in greater detail in Section 9. A detailed life cycle cost analysis for the individual facilities is included in Appendix D.

Table 15-5 Summary of Capital and O&M Costs for Alternative 3-4 (Thermal Hydrolysis at McAlpine Creek WWMF)

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
McAlpine Creek WWMF Direct Construction Costs	$23.68	$17.45	$41.12
Irwin Creek WWTP Direct Construction Costs	$2.46	$4.81	$7.27
Mallard Creek WRF Direct Construction Costs	$1.88	$0.92	$2.80
McDowell Creek WRF Direct Construction Costs	$0.00	$3.67	$3.67
Subtotal Direct Construction Costs	**$28.02**	**$26.85**	**$54.86**
Subtotal Indirect Construction Costs			**$39.06**
Total Capital Cost			**$93.92**
O&M Cost			**20-Year NPV ($M)**
Pre-Dewatering			$48.05
Pre-Treatment			$15.55
WAS Thickening			$13.19
An Dig			$8.61
Dewatering			$24.26
Land Application			$49.42
Total Net Present O&M Cost			$159.07
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			$253.00

15.2.5 Alternative 3-4 Greenhouse Gas Emissions Offset

The annual lifecycle greenhouse gas (GHG) (2016-2035) emissions associated with this alternative are presented in **Table 15-6**. Section 9.3.3 presents background information regarding greenhouses gas emissions and the model that was used to prepare the GHG emissions offset values.

Table 15-6 Greenhouse Gas Emissions for Alternative 3-4

Wastewater Treatment Facility	Metric Tons CO2 Equivalents per Year
McAlpine Creek WWMF	700
Irwin Creek WWTP	(900)
Mallard Creek WRF	700
McDowell Creek WRF	(350)
Total	**150**

15.3 Alternative 3-6: McAlpine Creek WWMF Thermal Hydrolysis & Irwin Creek WWTP Pumping

15.3.1 McAlpine Creek WWMF Process Description

This alternative is similar to Alternative 3-4, with the exception that McAlpine Creek WWMF receives and processes the liquid PS and WAS pumped from Irwin Creek WWTP. It is envisioned that the facilities at Irwin Creek WWTP would be phased out, with the exception of the dewatered solids storage facility, which may continue to store residuals from Franklin and Vest.

Figure 15-3 shows the process flow schematic for Alternative 3-6. The site layout in Figure 15-2 is also applicable to this alternative; with the exception that one additional equalization tank would be installed to receive solids pumped from Irwin Creek WWTP. A mass balance showing the increase in solids due to the Irwin Creek WWTP contribution is presented in **Table 15-7** for McAlpine Creek WWMF.

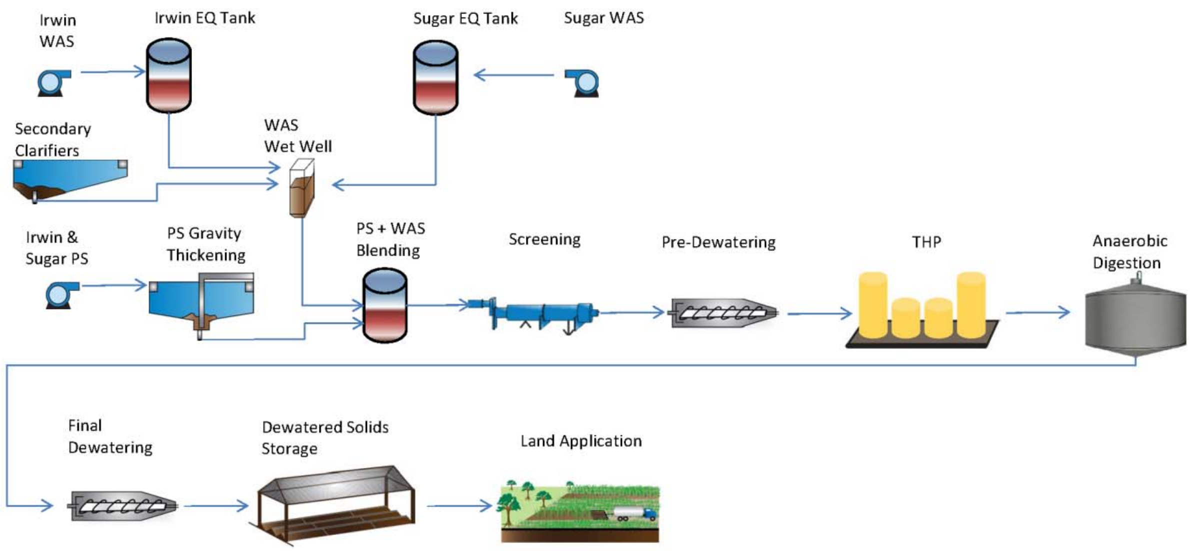

Figure 15-3
Alternative 3-6 McAlpine Creek WWMF
Process Flow Schematic

15.3.2 McAlpine Creek WWMF Facilities Required

The same facilities and equipment sizing and quantities discussed for Alternative 3-4 are still valid under this option, with the following exceptions:

- New Irwin Creek WWTP Equalization Tank: In addition to the 31,000 gal above-grade tank receiving WAS pumped from Sugar Creek WWTP, a similar tank will be provided for Irwin Creek WWTP WAS. The equalized flow from these two tanks will be discharged to the existing wet well, where it is mixed with WAS from McAlpine Creek WWMF. At a 14-day peak condition in year 2035, it is estimated that the two tanks will provide 2 hours of storage.
- PS and WAS Blending: Two new blend tanks will have a capacity of 42,000 gal each.
- RMF Expansion: The new dewatered cake storage facility will be 290 feet in length by 175 feet in width.
- The gravity thickeners at McAlpine Creek WWMF will receive the PS pumped from Irwin Creek WWTP.

Table 15-7 Alternative 3-6 McAlpine Creek WWMF Mass Balance for Year 2035 Max Month Conditions

Unit Process	PS	PS Gravity Thickening Discharge	WAS	THP Pre-Dewatering Feed	THP Feed	THP Effluent	Anaerobic Digestion Effluent	Centrifuge Dewatered Cake
Total SLR (dry ton/day)	78.0	74.1	48.6	122.7	116.6	116.6	59.2	56.3
TS Concentration (%)	0.3%	5.3%	0.8%	1.7%	17.0%	11.0%	5.6%	30.0%
Total HLR (gpd)	7,131,000	336,000	1,433,000	1,757,000	165,000	255,000	255,000	45,000
Total SLR (wet ton/d)	29,740	1,400	5,980	7,330	690	1,060	1,060	190

15.3.3 Irwin Creek WWTP Process Description

PS and WAS will be pumped to McAlpine Creek WWMF for treatment. It is anticipated that the remaining facilities at Irwin Creek WWTP would be phased out, with the exception of the Dewatered Cake Storage Facility, which could continue to receive solids from Franklin and Vest.

Table 15-8 summarizes the solids generated at Irwin Creek WWTP and transferred to McAlpine Creek WWMF for Alternative 3-6.

Table 15-8 Alternative 3-6 Irwin Creek WWTP Solids Production for Year 2035 Max Month Conditions

Unit Process	PS	WAS
Total SLR (dry ton/day)	10.3	6.4
TS Concentration (%)	0.9%	0.9%
Total HLR (gpd)	275,000	171,200
Total SLR (wet ton/d)	1,150	700

15.3.4 Irwin Creek WWTP Facilities Required

PS and WAS Pump Stations

Two new submersible wastewater pumps with an estimated capacity of 250 gpm each will be located in an existing tank (e.g., existing digesters) reconditioned for this new function, to transfer PS from Irwin Creek WWTP to the gravity thickeners at McAlpine Creek WWMF through a new six inch ductile iron force main. The new pipe would run along the same route where an existing sewer line is already installed for an approximate distance of 13.5 miles.

A second similar pump station consisting of two new submersible wastewater pumps with an estimated capacity of 250 gpm installed in an existing tank would deliver WAS to the new 31,000 gallon equalization tank at McAlpine Creek WWMF, prior to discharge to the existing WAS wet well, where it would blend with WAS from McAlpine Creek WWMF and Sugar Creek WWTP. A separate six inch force main would be used for the WAS flow.

Figure 15-4 shows the proposed route for the two force mains.

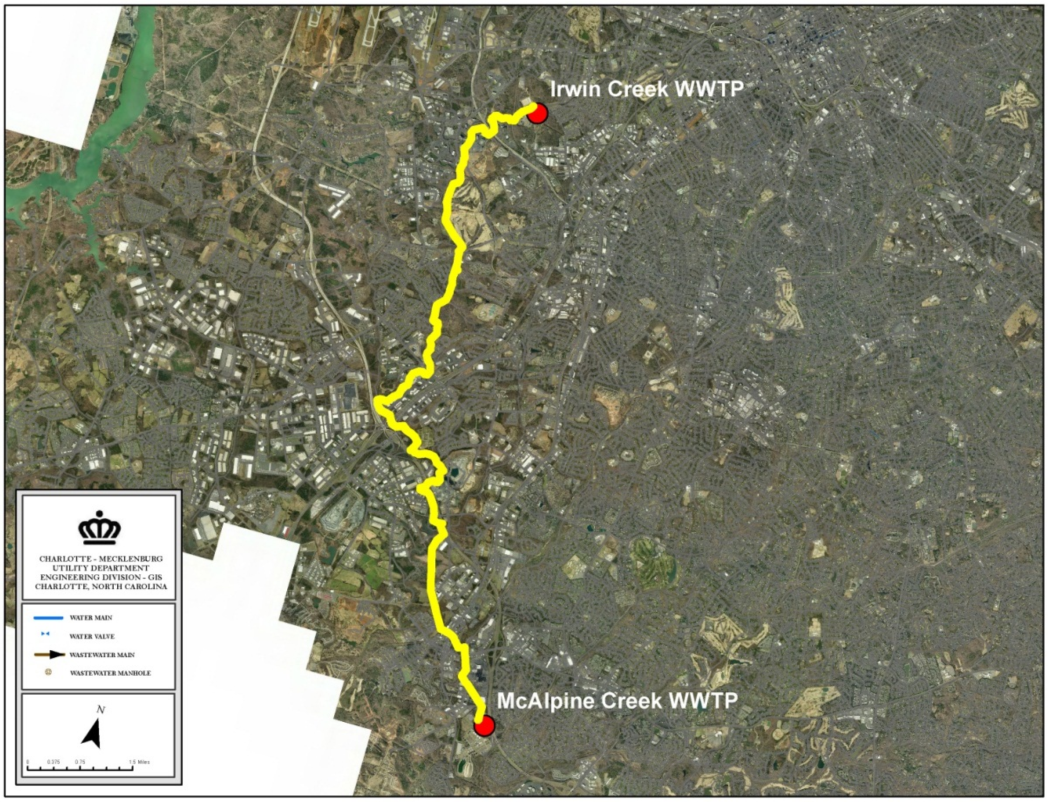

Figure 15-4
Irwin Creek WWTP Sludge Force Mains to McAlpine Creek WWMF

15.3.5 Mallard Creek WRF & McDowell Creek WRF

Process Description, Facilities Required and Total Present Worth

Under Alternative 3-6, Mallard Creek and Creek WRFs will not change their current operations. Therefore, the conclusions and life cycle results presented in Section 14 apply to these WWTPs.

15.3.6 Alternative 3-6 (McAlpine Creek WWMF Thermal Hydrolysis & Irwin Creek WWTP Pumping) Total Life Cycle Cost

Table 15-9 provides an opinion of probable construction and O&M cost for Alternative 3-6. In addition to direct construction costs (equipment, labor, and materials), capital cost estimates include a number of indirect costs, as illustrated in Table 9-1**.** Indirect construction costs include markups for taxes, permits, bonds, insurance, contractor's general conditions, overhead and profit, engineering services during design and construction, administrative costs, and contingency. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period. Development of costs is explained in greater detail in Section 9. A detailed life cycle cost analysis for the individual facilities is included in Appendix D.

Table 15-9 Summary of Capital and O&M Costs for Alternative 3-6 (THP at McAlpine Creek WWMF + Irwin Creek WWTP Pumping)

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
McAlpine Creek WWMF Direct Construction Costs	$24.42	$26.58	$50.99
Irwin Creek WWTP Direct Construction Costs	$0.16	$0.28	$0.44
Mallard Creek WRF Direct Construction Costs	$1.88	$0.92	$2.80
McDowell Creek WRF Direct Construction Costs	$0.00	$3.67	$3.67
Subtotal Direct Construction Costs	**$26.46**	**$31.45**	**$57.90**
Subtotal Indirect Construction Costs			**$41.02**
Total Capital Cost			**$98.92**
O&M Cost			**20-Year NPV ($M)**
Liquid Solids Transfer from Irwin Creek WWTP to McAlpine Creek WWMF			$0.30
Pre-Dewatering			$57.51
Pre-Treatment			$18.02
WAS Thickening			$9.63
An Dig			$6.23
Dewatering			$24.02
Land Application			$47.87
Total Net Present O&M Cost			**$163.59**
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			$262.60

15.3.7 Alternative 3-6 Greenhouse Gas Emissions Offset

The annual greenhouse gas emissions offset (2016-2035) for this Alternative is shown in **Table 15-10**. Section 9.3.3 presents background information regarding greenhouses gas emissions and the model that was used to prepare the GHG emissions offset values.

Table 15-10 Greenhouse Gas Emissions for Alternative 3-6

Wastewater Treatment Facility	Metric Tons CO2 Equivalents per Year
McAlpine Creek WWMF	900
Irwin Creek WWTP	-
Mallard Creek WRF	700
McDowell Creek WRF	(350)
Total	**1,250**

15.4 Alternative 3-7: Electrical Lysis at All WWTPs

15.4.1 McAlpine Creek WWMF Process Description

This alternative is substantially similar to Alternative 1-1 presented in Section 14, which maintains current operations, with the exception that an electrical lysis process (ELP) will be applied at all WWTPs to improve anaerobic digestion.

A process flow schematic and a site layout for Alternative 3-7 at McAlpine Creek WWMF are presented in **Figure 15-5** and **Figure 15-6**. **Table 15-11** summarizes the results of the mass balance.

Table 15-11 Alternative 3-7 McAlpine Creek WWMF Mass Balance for Year 2035 Max Month Conditions

Unit Process	PS	PS Gravity Thickening Discharge	WAS	WAS Centrifuge Thickening Discharge	Anaerobic Digestion Feed	Anaerobic Digestion Effluent	Centrifuge Dewatered Cake
Total SLR (dry ton/day)	66.2	62.9	39.8	37.8	100.6	56.0	53.2
TS Concentration (%)	0.23%	5.30%	0.80%	5.10%	5.22%	2.91%	18.40%
Total HLR (gpd)	6,815,000	285,000	1,198,000	178,000	463,000	463,000	70,000
Total SLR (wet ton/d)	28,416	1,186	4,995	741	1,927	1,927	289

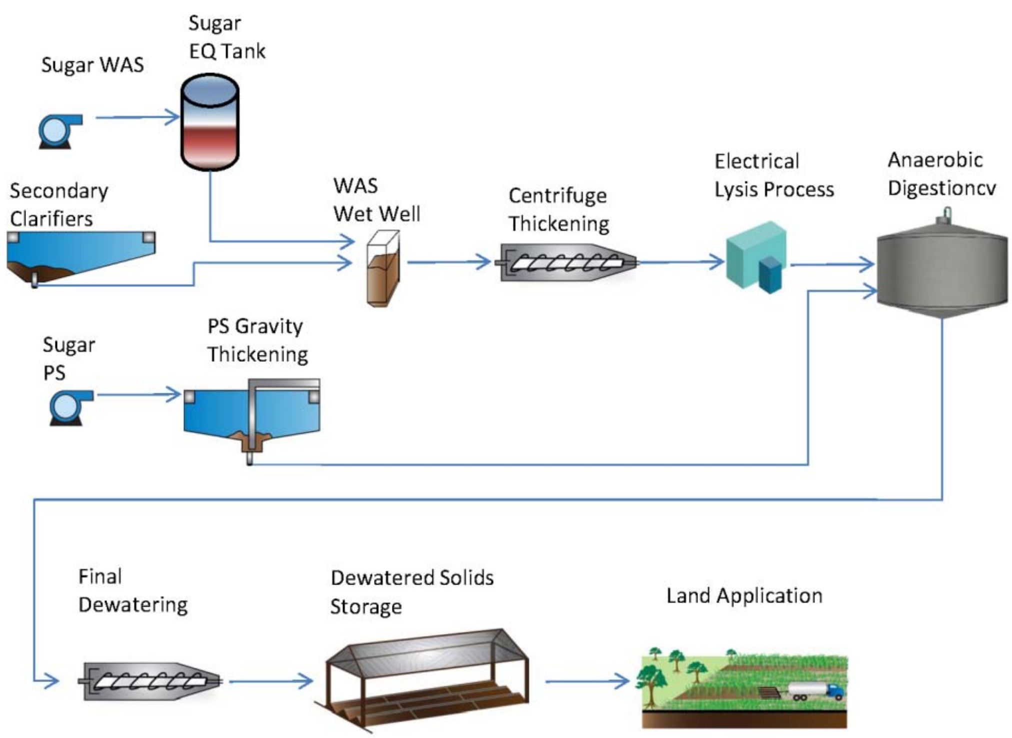

Figure 15-5
Alternative 3-7 McAlpine Creek WWMF Process Flow Schematic

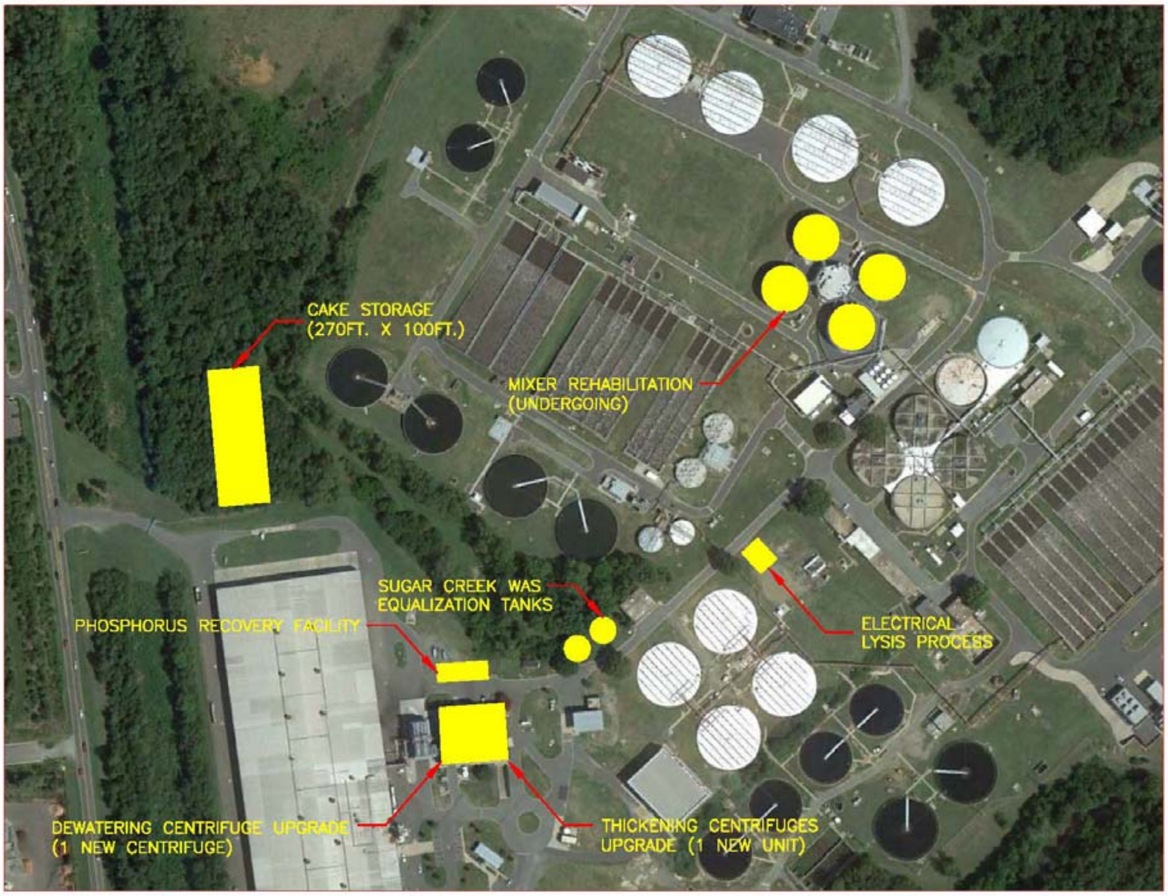

Figure 15-6
Alternative 3-7 McAlpine Creek WWMF Site Layout

15.4.2 Facilities Required at All WWTPs

Electrical Lysis Process

The design is based on models provided by OpenCEL treating the WAS stream only with high frequency electronic pulses prior to discharge to the digesters. This system is provided in a pre-engineered skid mounted configurations, consisting of the electrolysis pre-treatment system and associated auxiliaries including controls, lobe pumps, grinders, and external chiller unit.

The ELP is equipped with a pulse generator that coverts 400V AC power to high voltage pulses, to achieve cell lysis. These pulses are applied to a treatment chamber through which the WAS stream flows. This chamber is periodically slushed with filtered plant effluent. A cooling system with a chiller is supplied to protect the assembly from excessive heat. A macerating unit and a positive displacement pump feeds WAS to the treatment chamber.

The selected model for McAlpine Creek WWMF consists of three OC-300 units (or five, smaller, standard OC-150 units); while at the other facilities one OC-150 unit would be sufficient. The ELP system will be housed in a building dedicated to this process.

The budgetary equipment cost, prior to installation, for the McAlpine Creek WWMF system, comprised of three larger units, and for single unit proposed at the other plants is $6.9 million (M) and $1.5 M, respectively. Accounting for installation, taxes and contingencies, the opinion cost is $9.3 M at McAlpine Creek WWMF and $4.3 M at the other plants. This cost includes a small building to house the ELP system, while the chillers associated to each unit would be located outdoors, adjacent to the building.

Under Alternative 3-6, Mallard Creek and McDowell Creek WRFs will not change their current operations. Therefore, the conclusions and life cycle results presented in Section 14 apply to these WWTPs.

15.4.3 Alternative 3-7 (Electrical Lysis at All WWTPs) Total Life Cycle Cost

Table 15-12 provides an opinion of probable construction and O&M cost for Alternative 3-7. In addition to direct construction costs (equipment, labor, and materials), capital cost estimates include a number of indirect costs, as illustrated in Table 9-1**.** Indirect construction costs include markups for taxes, permits, bonds, insurance, contractor's general conditions, overhead and profit, engineering services during design and construction, administrative costs, and contingency. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period. Development of costs is explained in greater detail in Section 9. A detailed life cycle cost analysis for the individual facilities is included in Appendix D.

Table 15-12 Summary of Capital and O&M Costs for Alternative 3-7 (Electrical Lysis at All WWTPs)

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
McAlpine Creek WWMF Direct Construction Costs	$11.35	$12.09	$23.44
Irwin Creek WWTP Direct Construction Costs	$3.96	$5.61	$9.57
Mallard Creek WRF Direct Construction Costs	$3.38	$1.72	$5.10
McDowell Creek WRF Direct Construction Costs	$1.50	$4.47	$5.97
Subtotal Direct Construction Costs	**$20.19**	**$23.89**	**$44.08**
Subtotal Indirect Construction Costs			**$32.86**
Total Capital Cost			**$76.94**
O&M Cost			**20-Year NPV ($M)**
WAS Thickening			$35.80
Electrical Lysis			$5.72
An Dig			$12.99
Dewatering			$31.69
Land Application			$59.20
Total Net Present O&M Cost			$145.40
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			$222.40

15.4.4 Alternative 3-7 Greenhouse Gas Emissions Offset

The annual lifecycle greenhouse gas (GHG) emissions associated with this alternative are presented in **Table 15-13**. Section 9.3.3 presents background information regarding greenhouses gas emissions and the model that was used to prepare the GHG emissions offset values.

Table 15-13 Greenhouse Gas Emissions for Alternative 3-7

Wastewater Treatment Facility	Metric Tons CO2 Equivalents per Year
McAlpine Creek WWMF	5,600
Irwin Creek WWTP	(800)
Mallard Creek WRF	(1,300)
McDowell Creek WRF	(80)
Total	**3,420**

15.5 Alternative 3-8: McAlpine Creek WWMF Thermal Hydrolysis & Electrical Lysis at Other WWTPs

15.5.1 WWTPs Process Description and Facilities Requirements

This alternative provides thermal hydrolysis at McAlpine Creek WWMF coupled with electrical lysis at all other facilities. Therefore, the same considerations, sizing requirements and site layouts discussed in Alternative 3-4 for McAlpine Creek WWMF and in Alternative 3-7 for all other facilities apply to this scenario.

15.5.2 Alternative 3-8 (McAlpine Creek WWMF Thermal Hydrolysis & Electrical Lysis at Other WWTPs) Total Life Cycle Cost

Capital improvements and O&M costs required at all WWTPs for Alternative 3-8 are summarized in **Table 15-14.** They represent a combination of the costs for McAlpine Creek WWMF thermal hydrolysis in Alternative 3-4 and electrical lysis for the other facilities in Alternative 3-7. Table 15-14 provides an opinion of probable construction and O&M cost for the above facilities. In addition to direct construction costs (equipment, labor, and materials), capital cost estimates include a number of indirect costs, as illustrated in Table 9-1**.** Indirect construction costs include markups for taxes, permits, bonds, insurance, contractor's general conditions, overhead and profit, engineering services during design and construction, administrative costs, and contingency. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period. Development of costs is explained in greater detail in Section 9. A detailed life cycle cost analysis for the individual facilities is included in Appendix D.

Table 15-14 Summary of Capital and O&M Costs for Alternative 3-8 (McAlpine Creek WWMF Thermal Hydrolysis + Electrical Lysis at Other WWTPs)

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
McAlpine Creek WWMF Direct Construction Costs	$23.68	$17.45	$41.12
Irwin Creek WWTP Direct Construction Costs	$3.96	$5.61	$9.57
Mallard Creek WRF Direct Construction Costs	$3.38	$1.72	$5.10
McDowell Creek WRF Direct Construction Costs	$1.50	$4.47	$5.97
Subtotal Direct Construction Costs	**$32.52**	**$29.25**	**$61.76**
Subtotal Indirect Construction Costs			**$44.88**
Total Capital Cost			**$106.64**
O&M Cost			**20-Year NPV ($M)**
Pre-Dewatering			$48.05
Pre-Treatment			$15.55
WAS Thickening			$13.19
Electrical Lysis			$5.52
An Dig			$10.41
Dewatering			$26.19
Land Application			$55.16
Total Net Present O&M Cost			$174.06
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			$280.70

15.5.3 Alternative 3-8 Greenhouse Gas Emissions Offset

The annual lifecycle greenhouse gas (GHG) emissions associated with this alternative are presented in **Table 15-15**. Section 9.3.3 presents background information regarding greenhouses gas emissions and the model that was used to prepare the GHG emissions offset values.

Table 15-15 Greenhouse Gas Emissions for Alternative 3-8

Wastewater Treatment Facility	Metric Tons CO2 Equivalents per Year
McAlpine Creek WWMF	700
Irwin Creek WWTP	(800)
Mallard Creek WRF	(1,300)
McDowell Creek WRF	(80)
Total	**(1,480)**

Section 16

WWTP Drying Alternatives Evaluation

16.1 Overview of Drying Alternatives

This section evaluates the drying alternatives summarized in **Table 16-1**. These alternatives were identified from a preliminary screening process presented in Section 8, in which they were derived from the combination of management strategies at each WWTP. A detailed evaluation is presented for each alternative in the following, including design characteristics, non-monetary factors, and a life cycle cost analysis based on conceptual construction and annual O&M costs. This evaluation assumes that construction will be completed in year 2016. O&M costs are projected for the 20-year period between 2016 and 2035. The methodology for this analysis is further discussed in Section 9.

Table 16-1 Drying Alternatives for WWTP Biosolids Management

WWTP	Alternative 4-4	Alternative 4-12
McAlpine Creek WWMF	Add thermal dryer downstream of anaerobic digestion	Add thermal dryer downstream of anaerobic digestion
Irwin Creek WWTP	Maintain anaerobic digestion	Pump liquid sludge from Irwin Creek WWTP to McAlpine Creek WWMF for treatment
Mallard Creek WRF		Maintain anaerobic digestion
McDowell Creek WRF		Solar Drying

The following considerations apply to the alternatives in Table 16-1.

- **McAlpine Creek WWMF (All Drying Alternatives)**

  Thermal Drying – Rotary drum dryers are the prevalent type of dryer currently in use in the U.S. at medium to large facilities, and are proposed for evaluation at McAlpine Creek WWMF. They represent a direct drying process, in which the heated air comes in direct contact with the biosolids in the rotating drum, evaporates water and produces a dry hard pellet with a solids content above 90 percent. The pellets are stored in silos integral to the drying facility, and exhaust gases are treated to remove odor causing compounds and particulates. Fuel for heat drying may be natural gas or biogas.

  The dried material meets Class A biosolids requirements for pathogen reduction and has a significantly reduced volume, which facilitates transportation to more distant markets. It is also suitable for distribution and marketing as a fertilizer or soil conditioner.

- **McDowell Creek WRF (Alternative 4-12)**

  Solar Drying - Dewatered sludge cake is spread in a layer across the floor of several solar modules resembling greenhouses, and agitated by an automated roving machine. The combination of solar heat and constant agitation work together to speed the drying process, and solids content of 70 percent or higher may be achieved. Class A is a potential outlet, although this technology is not currently classified by EPA as a Process to Further Reduce Pathogens.

- **Irwin Creek WWTP & Mallard Creek WRF (All Drying Alternatives) and McDowell Creek WRF (Alternative 4-4)**

  Anaerobic Digestion – This management strategy is characterized by maintaining current operations with mesophilic anaerobic digestion, as discussed for Alternative 14.

16.2 Alternative 4-4: McAlpine Creek WWMF Thermal Drying

Alternative 4-4 couples anaerobic digestion followed by thermal drying at McAlpine Creek WWMF with no change in current operations at the other WWTPs.

16.2.1 McAlpine Creek WWMF Process Description

At McAlpine Creek WWMF, this alternative is substantially similar to Alternative 1-1 (i.e. maintenance of current operations) for all unit processes up to dewatering. The dewatered solids from the centrifuges are however dried in a thermal dryer rather than being land applied. The option of land applying still remains for emergencies.

A process flow schematic and a site layout for Alternative 4-4 at McAlpine Creek WWMF are presented in **Figure 16-1** and **Figure 16-2**. It is envisioned that the thermal dryer will be located in the vicinity of the Thickening/Dewatering Building to limit the distance to transfer dewatered cake. **Table 16-2** summarizes the results of the mass balance.

16.2.2 McAlpine Creek WWMF Facilities Required

WAS Equalization, Centrifuge Thickening and Phosphorus Removal

The following improvements upstream of the thermal dryer were discussed as part of Alternative 1-1 and are still applicable for Alternative 4-4. Refer to Section 14 for details.

- New Equalization Tank for WAS stream from Sugar Creek WWTP, located upstream of existing WAS wet well.
- Replacement of existing thickening centrifuges with a total of four units (of which one provides stand-by capabilities). Addition of one dewatering centrifuge to improve flexibility and reliability in operations. All thickening and dewatering equipment would be installed in the existing Thickening/Dewatering Building.
- Phosphorus removal system consisting of one fluidized bed reactor and storage building.

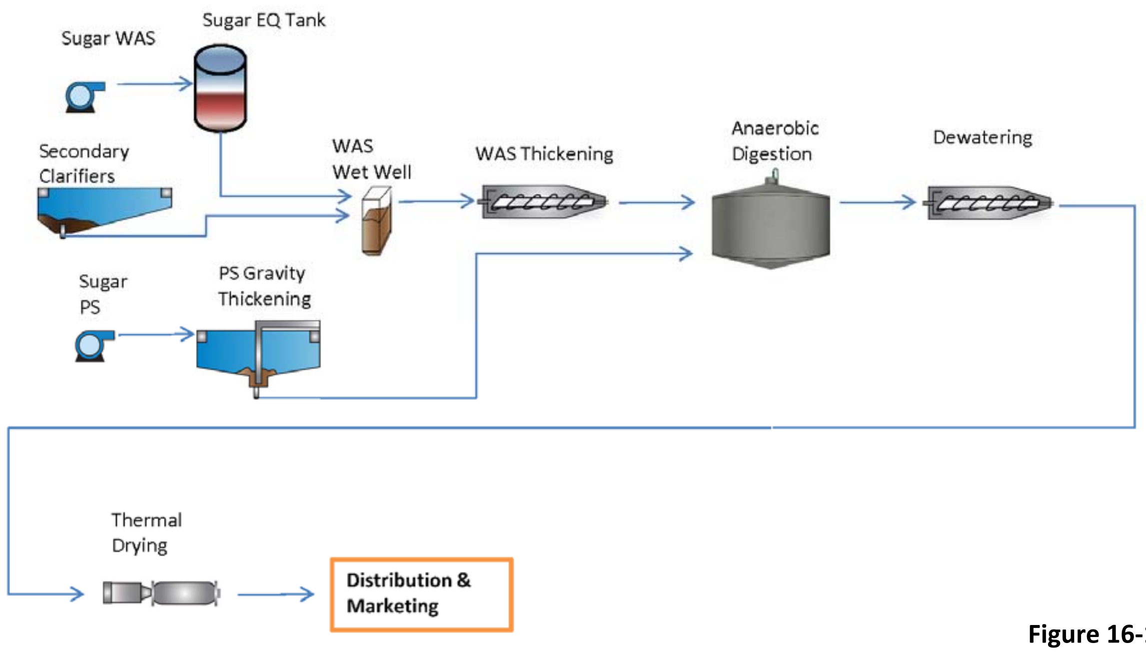

Figure 16-1
Alternative 4-4 McAlpine Creek WWMF Process Flow Schematic

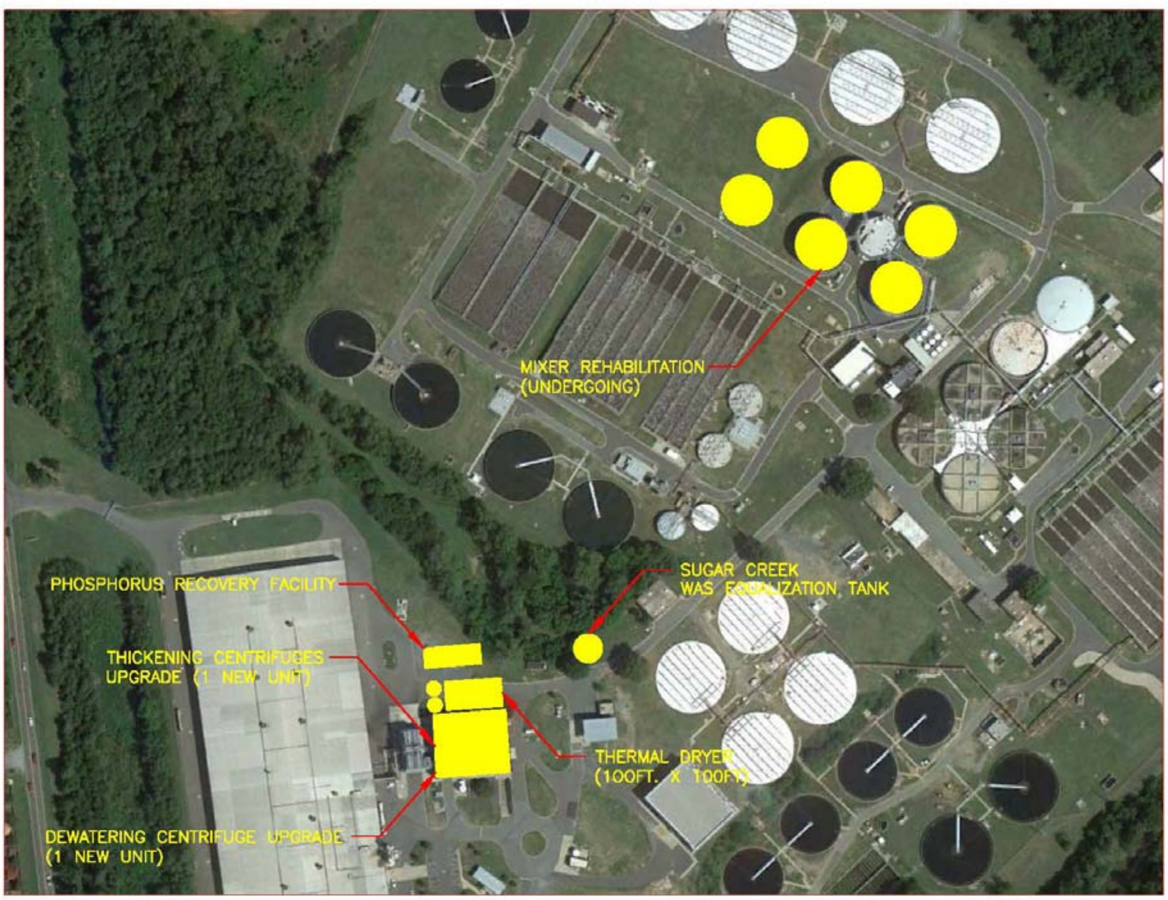

Figure 16-2
Alternative 4-4 McAlpine Creek WWMF Mass Balance for Year 2035 Max Month Conditions

Table 16-2 Alternative 4-4 McAlpine Creek WWMF Mass Balance for Year 2035 Max Month Conditions

Unit Process	PS	PS Gravity Thickening Discharge	WAS	WAS Centrifuge Thickening Discharge	Anaerobic Digester Feed	Anaerobic Digestion Discharge	Centrifuge Dewatered Cake	Thermal Dryer Pelletized Product
Total SLR (dry ton/day)	66.2	62.9	39.8	37.8	100.6	59.2	56.2	56.2
TS Concentration (%)	0.23%	5.30%	0.80%	5.10%	5.22%	3.07%	18.40%	90.00%
Total HLR (gpd)	6,814,300	284,400	1,197,900	177,600	462,200	462,200	73,300	15,000
Total SLR (wet ton/d)	28,420	1,190	5,000	740	1,930	1,930	310	60

Thermal Dryer System

The drying system will consist of two rotary drum dryer trains able to handle the max month conditions while operating 24x7 and the average month conditions while operating 5 days per week, 24 hours per day. Two dryers with the ability to evaporate 5 metric tons per hour of moisture each from the dewatered solids is proposed for this scenario.

The dryer system is installed in a building dedicated to the dryer, and is equipped with a regenerative thermal oxidizer (RTO) and two product storage silos with a 250 ton of dried product storage capacity. The estimated footprint of the building (excluding the RTO and the silos which are located outdoors) is 100 feet in length by 100 feet in width by 50 feet in height. The RTO is used to minimize air emissions, odors and noise.

The dryer uses mixing equipment to blend incoming dewatered biosolids with recycled dry material to achieve granulation/pelletization and produce a high quality Class A finished product for beneficial use. Advanced screening, cooling, and conveying systems will be used during transport of the dried material to the on-site storage silos.

Dewatered Cake Storage

The two silos that are integral to the dryer system will provide temporary storage for the dried material, prior to its distribution. Excluding the silos, it is estimated that the annual average production of 42 wet tons per day of pelletized product could be stored in the existing RMF for a period up to 120 days.

16.2.3 Irwin Creek WWTP, Mallard Creek WRF & McDowell Creek WRF

Process Description, Facilities Required and Total Present Worth

Under Alternative 4-4, Irwin Creek WWTP, Mallard Creek WRF and McDowell Creek WRF will not change their current operations. Therefore, the conclusions and life cycle results presented in Section 14 apply to these WWTPs.

16.2.4 Alternative 4-4 (McAlpine Creek WWMF Thermal Drying) Total Life Cycle Cost

Table 16-3 provides an opinion of probable construction and O&M cost for Alternative 4-4. The cost for Irwin Creek WWTP is similar to the cost for Alternative 1-1 but does not include the cost for the Dewatering Cake Storage Facility, which would not receive residuals from Vest and Franklin WTPs. A detailed life cycle cost analysis for the individual facilities is included in Appendix B. In addition to direct construction costs (equipment, labor, and materials), capital cost estimates include a number of indirect costs, as illustrated in Table 9-1**.** Indirect construction costs include markups for taxes, permits, bonds, insurance, contractor's general conditions, overhead and profit, engineering services during design and construction, administrative costs, and contingency. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period. Development of costs is explained in greater detail in Section 9.

Table 16-3 Summary of Capital and O&M Costs for Alternative 4-4 (Thermal Drying at McAlpine Creek WWMF)

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
McAlpine Creek WWMF Direct Construction Costs	$22.05	$20.10	$42.15
Irwin Creek WWTP Direct Construction Costs	$2.46	$4.81	$7.27
Mallard Creek WRF Direct Construction Costs	$1.88	$0.92	$2.80
McDowell Creek WRF Direct Construction Costs	$0.00	$3.67	$3.67
Subtotal Direct Construction Costs	$26.39	$29.50	$55.89
Subtotal Indirect Construction Costs			**$40.76**
Total Capital Cost			**$96.65**
O&M Cost			**20-Year NPV ($M)**
WAS Thickening			$35.80
Anaerobic Digestion			$11.19
Dewatering			$30.90
Thermal Drying			$65.40
Land Application			$17.68
Total Net Present O&M Cost[2]			$160.97
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			$257.62

16.2.5 Alternative 4-4 Greenhouse Gas Emissions Offset

The annual lifecycle greenhouse gas (GHG) emissions associated with this alternative are presented in **Table 16-4**. Section 9.3.3 presents background information regarding greenhouses gas emissions and the model that was used to prepare the GHG emissions offset values.

Table 16-4 Greenhouse Gas Emissions for Alternative 4-4

Wastewater Treatment Facility	Metric Tons CO2 Equivalents per Year
McAlpine Creek WWMF	24,000
Irwin Creek WWTP	(900)
Mallard Creek WRF	700
McDowell Creek WRF	(350)
Total	**24,450**

16.3 Alternative 4-12: McAlpine Creek WWMF Thermal Drying & McDowell Creek WRF Solar Drying

Alternative 4-12 is similar to Alternative 4-4, with anaerobic digestion followed by thermal drying at McAlpine Creek WWMF, and no change in current operations at Irwin Creek WWTP and Mallard Creek WRF. However, solar drying will be provided at McAlpine Creek WWMF, downstream of the current dewatering process.

16.3.1 McAlpine Creek WWMF, Irwin Creek WWTP and Mallard Creek WRF

Process Description, Facilities Required and Total Present Worth

McAlpine Creek WWMF, Irwin Creek WWTP, Mallard Creek WRF will implement the same management strategies presented in Alternative 4-4 for this facilities. Therefore, the conclusions and life cycle results presented for that alternative apply to these WWTPs.

16.3.2 McDowell Creek WRF Process Description

The only variation from Alternative 1-1 (i.e., maintenance of current operations) at McDowell Creek WRF consists in the addition of solar drying downstream of the dewatering belt filter presses. A dewatered cake storage facility will still be used to store the final product from the dryer. This will have minimum impact on current operations at McDowell Creek WRF, with the advantage of a reduced volume of dewatered solids to be disposed of. It is possible that the dryed solids could be distributed and marketed, for example as fertilizer. For this reason, it is assumed that the disposal practices at McDowell Creek WRF will be cost neutral.

A process flow schematic and a site plan of the McDowell Creek WRF improvements are presented in **Figure 16-3** and **Figure 16-4** for reference. **Table 16-5** summarizes the mass balance for McDowell Creek WRF. Note that while the historical performance of the BFPs is of concern and averages 13% solids, it is assumed that this issue will be corrected by the time the solar dryer will be functional. According to the suppliers, a minimum feed solids concentration of 15% is required for the solar dryers to function properly.

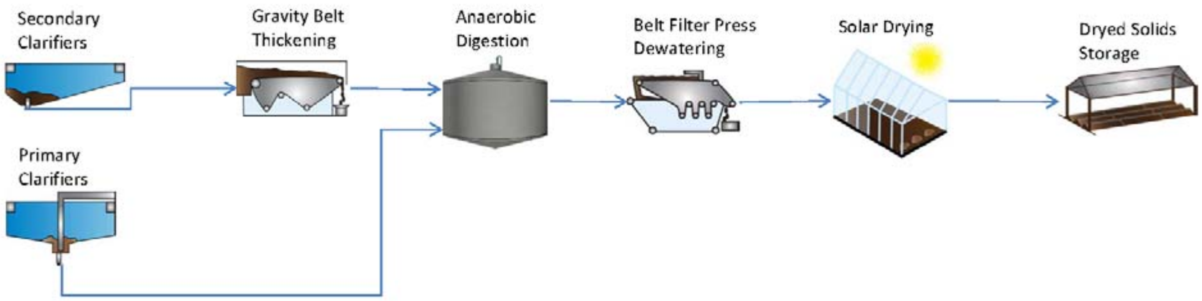

Figure 16-3
Alternative 4-12 McDowell Creek WRF Process Flow Schematic

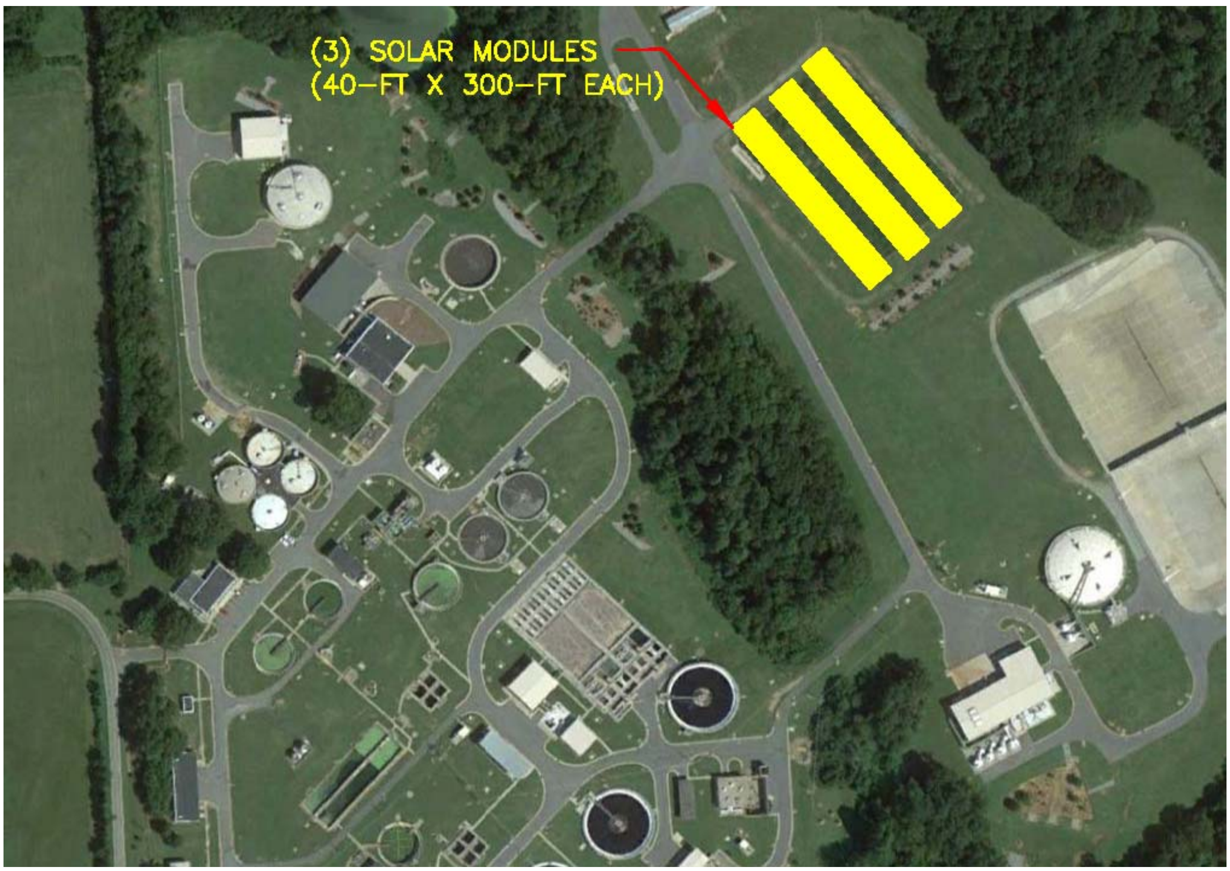

Figure 16-4
Alternative 4-12 McDowell Creek WRF Site Layout

Table 16-5 Alternative 4-12 McDowell Creek WRF Mass Balance for Year 2035 Max Month Conditions

Unit Process	PS	WAS	WAS Gravity Belt Thickening Effluent	Digester Feed	Anaerobic Digesters Effluent	Belt Filter Press Effluent	Solar Drying
Total SLR (dry ton/day)	5.4	4.9	4.6	10.0	5.9	5.6	5.6
TS Concentration (%)	3.40%	0.70%	4.00%	3.65%	2.16%	15.00%	75.00%
Total HLR (gpd)	37,900	167,600	27,900	65,700	65,700	9,000	1,800
Total SLR (wet ton/d)	160	700	120	280	280	38	8

16.3.3 McDowell Creek WRF Facilities Required

Solar Dryer System

Dewatered cake is transported by truck from the dewatering facility to the solar drying modules. The solar drying process consists of 3 individual solar modules (greenhouses) equipped with automated climate control and autonomous rototilling devices that mix, aerate and distribute the biosolids unloaded to each module with front end loaders. The facilities are capable of drying biosolids from a minimum 15% to 75% solids, based upon average climatic conditions for Charlotte. Each module is approximately 100-ft wide by 340-ft long.

Sizing of the solar dryers is based on the ability to dry future solids projected for year 2035 under annual average conditions, not max month conditions. Each module would be capable to dry approximately 1.5 dry tons per day.

Dewatered Cake Storage

A smaller expansion of the existing Dewatered Solids Storage Facility will be required with comparison to the one proposed as part of Alternative 1-1. This is due to the higher solids concentration of the dried solids, which is anticipated to reach 75%. A facility expansion, required to provide 120 days of storage up to year 2035 will measure 65 feet in length by 50 feet in width and will be located adjacent to the existing facility.

16.3.4 Alternative 4-12 (McAlpine Creek WWMF Thermal Drying & McDowell Creek WRF Solar Drying) Total Life Cycle Cost

Table 16-6 provides an opinion of probable construction and O&M cost for Alternative 4-12. In addition to direct construction costs (equipment, labor, and materials), capital cost estimates include a number of indirect costs, as illustrated in Table 9-1**.** Indirect construction costs include markups for taxes, permits, bonds, insurance, contractor's general conditions, overhead and profit, engineering services during design and construction, administrative costs, and contingency. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period. Development of costs is explained in greater detail in Section 9. A detailed life cycle cost analysis for the individual facilities is included in Appendix B.

Table 16-6 Summary of Capital and O&M Costs for Alternatives 4-12 (McAlpine Creek WWMF Thermal Drying & McDowell Creek WRF Solar Drying)

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
McAlpine Creek WWMF Direct Construction Costs	$22.05	$20.10	$42.15
Irwin Creek WWTP Direct Construction Costs	$2.46	$4.81	$7.27
Mallard Creek WRF Direct Construction Costs	$1.88	$0.92	$2.80
McDowell Creek WRF Direct Construction Costs	$5.53	$4.55	$10.08
Subtotal Direct Construction Costs	$31.92	$30.38	$62.30
Subtotal Indirect Construction Costs			**$45.69**
Total Capital Cost			**$107.99**
O&M Cost			**20-Year NPV ($M)**
WAS Thickening			$35.80
An Dig			$11.19
Dewatering			$30.90
Thermal Drying			$65.40
Land Application			$12.85
Solar Drying			$3.62
Total Net Present O&M Cost			$159.76
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			$267.75

16.3.5 Alternative 4-12 Greenhouse Gas Emissions Offset

The annual lifecycle greenhouse gas (GHG) emissions associated with this alternative are presented in **Table 16-7**. Section 9.3.3 presents background information regarding greenhouses gas emissions and the model that was used to prepare the GHG emissions offset values.

Table 16-7 Greenhouse Gas Emissions for Alternative 4-12

Wastewater Treatment Facility	Metric Tons CO2 Equivalents per Year
McAlpine Creek WWMF	24,000
Irwin Creek WWTP	(900)
Mallard Creek WRF	700
McDowell Creek WRF	-
Total	**23,800**

Section 17

WWTP Pre-Treatment & Drying Alternatives Evaluation

17.1 Overview of Pre-Treatment & Drying Alternatives

This section evaluates the pre-treatment alternatives summarized in **Table 17-1**.

Table 17-1 Pre-Treatment Alternatives for WWTP Biosolids Management

<table>
<tr><th>WWTP</th><th>Alternative 3+4-1</th><th>Alternative 3+4-2</th><th>Alternative 3+4-2</th></tr>
<tr><td>McAlpine Creek WWMF</td><td colspan="3">Add thermal hydrolysis upstream of anaerobic digestion followed by thermal drying</td></tr>
<tr><td>Irwin Creek WWTP</td><td rowspan="3">Maintain anaerobic digestion</td><td>Pump liquid sludge from Irwin Creek WWTP to McAlpine Creek WWMF for treatment</td><td>Pump liquid sludge from Irwin Creek WWTP to McAlpine Creek WWMF for treatment</td></tr>
<tr><td>Mallard Creek WRF</td><td rowspan="2">Maintain anaerobic digestion</td><td rowspan="2">Add electrical lysis upstream of anaerobic digestion</td></tr>
<tr><td>McDowell Creek WRF</td></tr>
</table>

These alternatives were identified from a preliminary screening process presented in Section 8, in which they were derived from the combination of management strategies at each WWTP. A detailed evaluation is presented for each alternative in the following, including design characteristics, non-monetary factors, and a life cycle cost analysis based on conceptual construction and annual O&M costs. This evaluation assumes that construction will be completed in year 2016. O&M costs are projected for the 20-year period between 2016 and 2035. The methodology for this analysis is further discussed in Section 9.

The following considerations apply to the alternatives in Table 17-1.

- **McAlpine Creek WWMF (All Alternatives)**

  Thermal Hydrolysis Coupled with Anaerobic Digestion and Thermal Drying – Thermal hydrolysis and thermal drying were discussed separately in Sections 15 and 16. Their combined use increases the capital and maintenance cost substantially, but also offers important benefits.

  The final product obtained with thermal hydrolysis meets Class A biosolids requirements and is greatly reduced in volume, while biogas production increases with respect to conventional digestion. However, the biosolids from thermal hydrolysis would need to be disposed of, typically by means of land application, landfill cover or through soil blending. Thermal drying downstream of thermal hydrolysis and digestion further reduces the volume of the biosolids, and converts them into a pelletized product that can be potentially distributed and marketed (e.g., as a fertilizer or soil conditioner), instead of being land applied.

- **Irwin Creek WWTP (Alternative 3+4-1) and Mallard Creek WRF & McDowell Creek WRF (Alternatives 3+4-1 & 3+4-2)**

  Anaerobic Digestion – This management strategy is characterized by maintaining current operations with mesophilic anaerobic digestion (refer to Section 14).

- **Irwin Creek WWTP (Alternative 3+4-2)**

  Sludge Transfer to McAlpine Creek WWMF – Unthickened PS and WAS at a solids concentration of less than 1 percent will be pumped to McAlpine Creek WWMF for processing and handling (refer to Section 15).

- **Irwin Creek WWTP, Mallard Creek WRF & McDowell Creek WRF (Alternatives 3+4-3)**

  Electrical Lysis with Anaerobic Digestion – High frequency electronic pulses are applied to the WAS stream, rupturing cell membranes and releasing soluble material that can improve VSR and biogas generation (refer to Section 15).

17.2 Alternative 3+4-1: McAlpine Creek WWMF Thermal Hydrolysis & Drying

Alternative 3+4-1 couples thermal hydrolysis followed by anaerobic digestion and thermal drying at McAlpine Creek WWMF with no change in current operations at the other WWTPs.

17.2.1 McAlpine Creek WWMF Process Description

At McAlpine Creek WWMF, the process flow train will include the same unit processes discussed for thermal hydrolysis in Alternative 3-4, including: blending of WAS and PS, screening, pre-dewatering followed by thermal hydrolysis, anaerobic digestion and final dewatering. The stabilized biosolids will then be fed to the thermal dryer system consisting of one rotary drum dryer producing a pelletized Class A material ready for distribution and marketing.

A process flow schematic and a site layout for Alternative 3+4-1 at McAlpine Creek WWMF are presented in **Figure 17-1** and **Figure 17-2**. It is proposed that the thermal hydrolysis process will be located in the opening space west of the anaerobic digesters, while the thermal dryer will be positioned in the vicinity of the Thickening/Dewatering Building to limit the distance to transfer dewatered cake. **Table 17-2** summarizes the results of the mass balance.

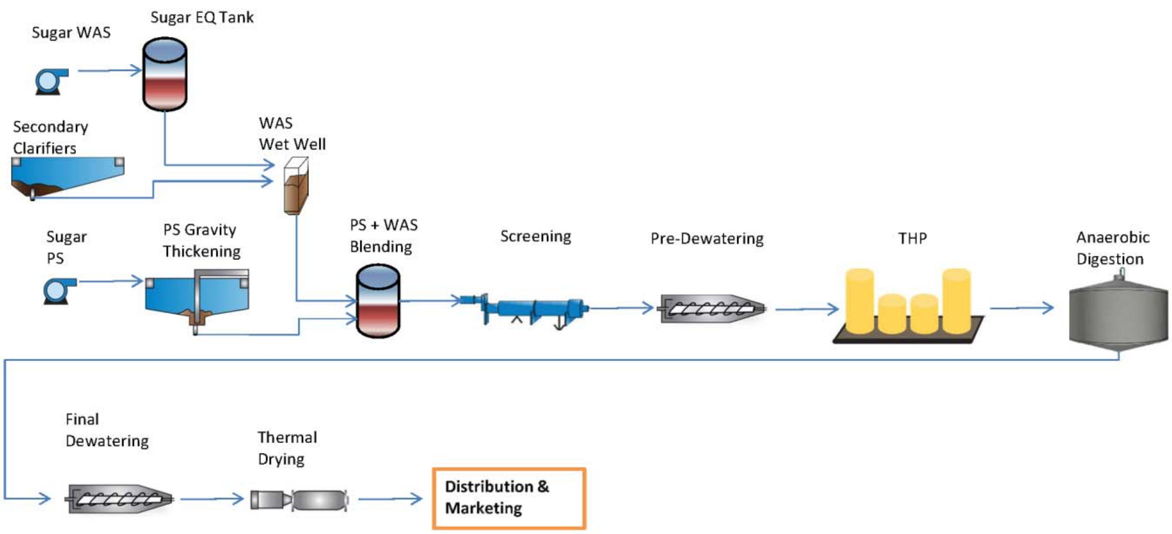

Figure 17-1
Alternative 3+4-1 McAlpine Creek WWMF Process Flow Schematic

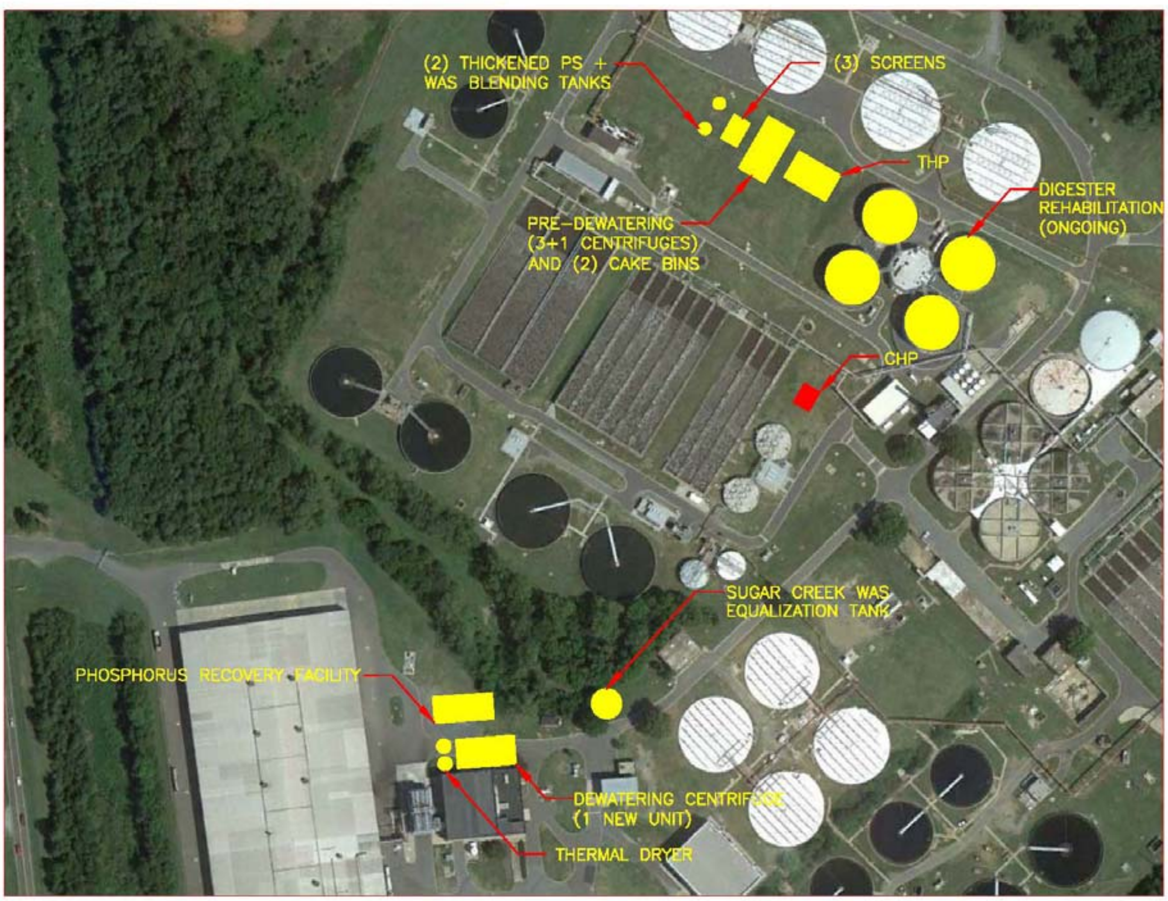

Figure 17-2
Alternative 3+4-1 McAlpine Creek WWMF Site Layout

Table 17-2 Alternative 3+4-1 McAlpine Creek WWMF Mass Balance for Year 2035 Max Month Conditions

Unit Process	PS	PS Gravity Thickening Discharge	WAS	THP Pre-Dewatering Feed	THP Pre-Dewatering Discharge	THP Effluent	Anaerobic Digestion Effluent	Centrifuge Dewatered Cake	Thermal Dryer Pelletized Product
Total SLR (dry ton/day)	66	63	39.8	103	97	97	49.4	46.9	46.9
TS Concentration (%)	0.2%	5.3%	0.8%	1.6%	17.0%	11.0%	5.6%	30.0%	90.0%
Total HLR (gpd)	6,815,000	285,000	1,198,000	1,511,000	138,000	213,000	213,000	38,000	13,000
Total SLR (wet ton/d)	28,420	1,190	5,000	6,300	580	890	890	160	60

17.2.2 McAlpine Creek WWMF Facilities Required

Improvements Associated to Thermal Hydrolysis

The following improvements upstream of the thermal dryer were discussed as part of Alternative 3-4 and are still applicable for Alternative 3+4-1. Refer to Section 15 for details.

- Equalization Tank: One 31,000 gal equalization tank for WAS stream from Sugar Creek WWTP, located upstream of existing WAS wet well.
- Blending Tanks: Two 35,000 gal blending tanks to blend thickened WAS and PS.
- Pre-Screening: three horizontal in-line coarse screens to remove coarse material prior to thermal hydrolysis.
- Pre-Dewatering: The three existing thickening centrifuges and one new unit to provide stand-by capacity will be located in a new Pre-Dewatering Building to pre-dewater the solids feeding the thermal hydrolysis process to approximately 17% solids.
- Thermal Hydrolysis Process: Two trains including three reactors each, pulper and flash tank (per Cambi's design) to hydrolyze the sludge and produce a Class A product. Veolia provides a system with different mechanical components but a final product of similar characteristics.
- Existing Anaerobic Digesters: The four newer digesters will be equipped with cooling heat exchangers, used to cool the hydrolyzed sludge from approximately 194 degrees Fahrenheit to mesophilic temperatures and auxiliaries such as solids and cooling water pumps.
- Final Dewatering: In addition to the two existing dewatering centrifuges, a new unit will be added to increase flexibility in operations. The new unit will be located in the existing Thickening/Dewatering Building to dewater the stabilized solids from the digesters.
- Phosphorus removal system consisting of one fluidized bed reactor and storage building.

Improvements Associated to Thermal Drying

According to Alternative 3+4-1, the thermal drying system will be installed downstream of the final dewatering system. There will be a single rotary drum dryer with the ability to evaporate four metric tons per hour of moisture from the dewatered solids. This unit will handle the max month conditions while operating 24x7 and the average month conditions while operating 5 days per week, 24 hours per day.

The dryer system will be installed in a building dedicated to the dryer, and is equipped with a regenerative thermal oxidizer (RTO) and two product storage silos with a 250 ton of dried product storage capacity. For comparison, Alternative 4-4 with thermal drying would require two larger dryer to process the higher volume of wet solids remaining after digestion and dewatering in the absence of thermal hydrolysis.

Even with a single dryer, it was assumed that the estimated footprint of the building (excluding the RTO and the silos which are located outdoors) would remain 90 feet in length by 45 feet in width by 50 feet in height. The RTO is used to minimize air emissions, odors and noise.

The dryer uses mixing equipment to blend incoming dewatered biosolids with recycled dry material to achieve granulation/pelletization and produce a high quality Class A finished product for beneficial use. Advanced screening, cooling, and conveying systems will be used during transport of the dried material to the on-site storage silos.

Dewatered Cake Storage

The two silos that are integral to the dryer system will provide temporary storage for the dried material, prior to its distribution. Even not accounting for the silos, it is forecasted that the annual average production of 50 wet tons per day of pelletized product could be stored in the existing RMF for a period of 120 days.

17.2.3 Irwin Creek WWTP, Mallard Creek WRF & McDowell Creek WRF

Process Description, Facilities Required and Total Present Worth

Under Alternative 3+4-1, Irwin Creek WWTP, Mallard Creek WRF and McDowell Creek WRF will not change their current operations. Therefore, the conclusions and life cycle results presented in Section 14 apply to these WWTPs. The only exception consists in the cost for Irwin Creek WWTP, which will not include the expansion of the Dewatered Cake Storage Facility. It is envisioned that this facility will only store solids from Irwin Creek WWTP, while Franklin and Vest residuals will be stored in a new facility at Franklin.

17.2.4 Alternative 3+4-1 (McAlpine Creek WWMF Thermal Hydrolysis & Drying) Total Life Cycle Cost

Table 17-3 provides an opinion of probable construction and O&M cost for the above facilities. In addition to direct construction costs (equipment, labor, and materials), capital cost estimates include a number of indirect costs, as illustrated in Table 9-1**.** Indirect construction costs include markups for taxes, permits, bonds, insurance, contractor's general conditions, overhead and profit, engineering services during design and construction, administrative costs, and contingency. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period. Development of costs is explained in greater detail in Section 9. A detailed life cycle cost analysis for the individual facilities is included in Appendix C.

Table 17-3 Summary of Capital and O&M Costs for Alternative 3+4-1 (McAlpine Creek WWMF Thermal Hydrolysis & Drying)

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
McAlpine Creek WWMF Direct Construction Costs	$31.58	$19.93	$51.50
Irwin Creek WWTP Direct Construction Costs	$2.46	$4.81	$7.27
Mallard Creek WRF Direct Construction Costs	$1.88	$0.92	$2.80
McDowell Creek WRF Direct Construction Costs	$0.00	$3.67	$3.67
Subtotal Direct Construction Costs	**$35.92**	**$29.33**	**$65.25**
Subtotal Direct Construction Costs			**$47.55**
Total Capital Cost			**$112.80**
O&M Cost			**20-Year NPV ($M)**
Pre-Dewatering			$48.05
Pre-Treatment			$15.55
WAS Thickening			$13.19
Anaerobic Digestion			$8.61
Dewatering			$24.26
Thermal Drying			$33.16
Land Application			$17.68
Total Net Present O&M Cost			$160.48
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			$273.30

17.2.5 Alternative 3+4-1 Greenhouse Gas Emissions Offset

The annual lifecycle greenhouse gas (GHG) emissions associated with this alternative are presented in **Table 17-4**. Section 9.3.3 presents background information regarding greenhouses gas emissions and the model that was used to prepare the GHG emissions offset values.

Table 17-4 Greenhouse Gas Emissions for Alternative 3+4-1

Wastewater Treatment Facility	Metric Tons CO2 Equivalents per Year
McAlpine Creek WWMF	9,000
Irwin Creek WWTP	(900)
Mallard Creek WRF	700
McDowell Creek WRF	(350)
Total	**8,450**

17.3 Alternative 3+4-2: McAlpine Creek WWMF Thermal Hydrolysis & Drying with Irwin Creek WWTP Pumping

Alternative 3+4-2 for McAlpine Creek WWMF is based on Alternative 3+6 with the addition of thermal drying downstream of thermal hydrolysis and anaerobic digestion. McAlpine Creek WWMF will treat the additional solids pumped from Irwin Creek WWTP, where it is anticipated that most facilities will be phased out, except for the Dewatered Cake Storage Facility.

A process flow schematic for Alternative 3+4-2 and a site layout are shown in **Figure 17-3** and Figure 17-2, with the only difference that one additional equalization tank would be provided for the sludge pumped from Irwin Creek WWTP. A mass balance showing the increase in solids due to the Irwin Creek WWTP contribution is presented in **Table 17-5** for McAlpine Creek WWMF.

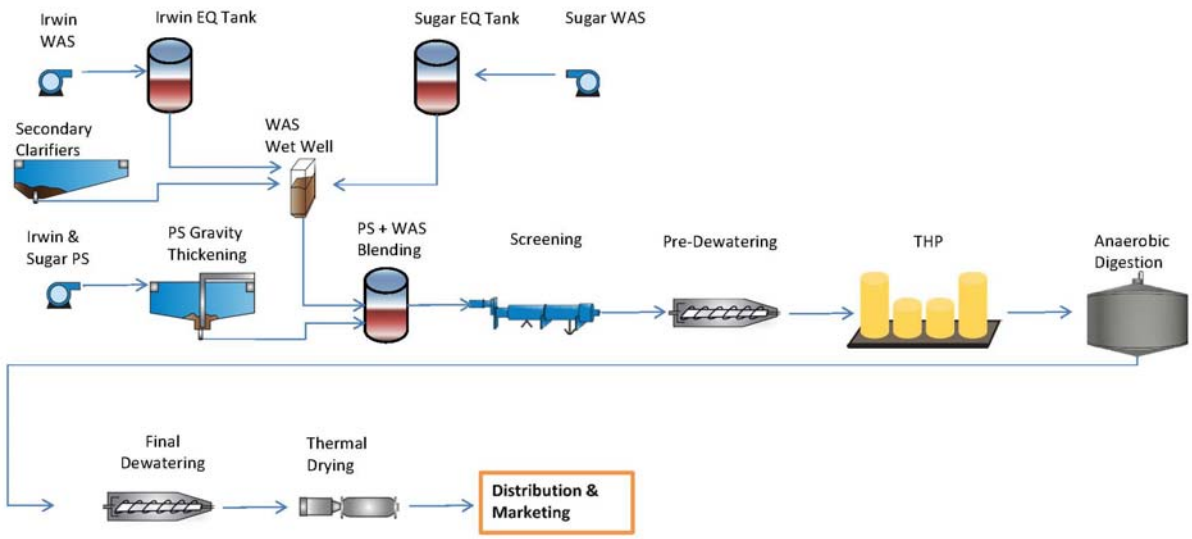

Figure 17-3
Alternative 3+4-2 McAlpine Creek WWMF Process Flow Schematic

17.3.1 McAlpine Creek WWMF Facilities Required

Improvements Associated to Thermal Hydrolysis

The same requirements discussed for Alternative 3+4-1 are still applicable, with the following variations. In particular, no variations in the thermal hydrolysis process, number of required digesters and phosphorus removal system are anticipated due to the increased volume of solids from Irwin Creek WWTP.

- Additional Equalization Tank: Second 31,000 gal equalization tank receiving WAS from Irwin Creek WWTP, discharging to the existing WAS wet well.
- Blending Tanks: Two 35,000 gal blending tanks to blend thickened WAS and PS.
- The gravity thickeners at McAlpine Creek WWMF will receive the PS pumped from Irwin Creek WWTP.
- Thermal Drying System: the thermal dryer will be similar to the one presented in Alternative 3+4-1 and consisting of a single rotary drum dryer, but will be slightly larger in size, with a capacity to evaporate five metric tons per hour of moisture from the dewatered solids.

Table 17-5 Alternative 3+4-2 McAlpine Creek WWMF Mass Balance for Year 2035 Max Month Conditions

Unit Process	PS	PS Gravity Thickening Discharge	WAS	THP Pre-Dewatering Feed	THP Pre-Dewatering Discharge	THP Effluent	Anaerobic Digestion Effluent	Centrifuge Dewatered Cake	Thermal Dryer Pelletized Product
Total SLR (dry ton/day)	78	74	48.6	123	117	117	59.2	56.3	56.3
TS Concentration (%)	0.3%	5.3%	0.8%	1.7%	17.0%	11.0%	5.6%	30.0%	90.0%
Total HLR (gpd)	7,131,000	336,000	1,433,000	1,757,000	165,000	255,000	255,000	45,000	15,000
Total SLR (wet ton/d)	29,740	1,400	5,980	7,330	690	1,060	1,060	190	70

17.3.2 Irwin Creek WWTP, Mallard Creek WRF & McDowell Creek WRF

Process Description, Facilities Required and Total Present Worth

Under Alternative 3+4-2, Irwin Creek WWTP transfer of solids to McAlpine Creek WWMF, and maintenance of current operations at Mallard Creek WRF and McDowell Creek WRF will be consistent with the results presented for Alternative 3-6 in Section 15.

17.3.3 Alternative 3+4-2 (McAlpine Creek WWMF Thermal Hydrolysis & Drying with Irwin Creek WWTP Pumping) Total Life Cycle Cost

Table 17-6 provides an opinion of probable construction and O&M cost for the above facilities. In addition to direct construction costs (equipment, labor, and materials), capital cost estimates include a number of indirect costs, as illustrated in Table 9-1**.** Indirect construction costs include markups for taxes, permits, bonds, insurance, contractor's general conditions, overhead and profit, engineering services during design and construction, administrative costs, and contingency. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period. Development of costs is explained in greater detail in Section 9. A detailed life cycle cost analysis for the individual facilities is included in Appendix C.

Table 17-6 Summary of Capital and O&M Costs for Alternative 3+4-2 (McAlpine Creek WWMF Thermal Hydrolysis & Drying with Irwin Creek WWTP Pumping)

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
McAlpine Creek WWMF Direct Construction Costs	$32.92	$28.34	$61.25
Irwin Creek WWTP Direct Construction Costs	$0.16	$0.28	$0.44
Mallard Creek WRF Direct Construction Costs	$1.88	$0.92	$2.80
McDowell Creek WRF Direct Construction Costs	$0.00	$3.67	$3.67
Subtotal Direct Construction Costs	**$34.22**	**$33.00**	**$67.22**
Subtotal Indirect Construction Costs			**$50.53**
Total Capital Cost			**$117.75**
O&M Cost			**20-Year NPV ($M)**
Pre-Dewatering			$58.68
Pre-Treatment			$17.87
WAS Thickening			$9.63
Anaerobic Digestion			$6.24
Dewatering			$23.31
Thermal Drying			$50.54
Land Application			$9.69
Irwin Creek WWTP Sludge Pumping Operations			$0.30
Total Net Present O&M Cost			$176.25
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			$294.10

17.3.4 Alternative 3+4-2 Greenhouse Gas Emissions Offset

The annual lifecycle greenhouse gas (GHG) emissions associated with this alternative are presented in **Table 17-7.** Section 9.3.3 presents background information regarding greenhouses gas emissions and the model that was used to prepare the GHG emissions offset values.

Table 17-7 Greenhouse Gas Emissions for Alternative 3+4-2

Wastewater Treatment Facility	Metric Tons CO2 Equivalents per Year
McAlpine Creek WWMF	11,000
Irwin Creek WWTP	-
Mallard Creek WRF	700
McDowell Creek WRF	(350)
Total	**11,350**

17.4 Alternative 3+4-3: McAlpine Creek WWMF Thermal Hydrolysis & Drying with Electrical Lysis at Other WWTPs

Alternative 3+4-3 for McAlpine Creek WWMF is the same as with Alternative 3+4+1. All other facilities will instead use electrical lysis to process WAS prior to digestion, similar to Alternative 3-7.

A process flow schematic for Alternative 3+4-3 and a site layout of McAlpine Creek WWMF are shown in Figure 17-1 and Figure 17-2. A mass balance is presented in Table 17-2.

17.4.1 Alternative 3+4-3 (McAlpine Creek WWMF Thermal Hydrolysis & Drying with Electrical Lysis at Other WWTPs) Total Life Cycle Cost

Table 17-8 provides an opinion of probable construction and O&M cost for the above facilities. In addition to direct construction costs (equipment, labor, and materials), capital cost estimates include a number of indirect costs, as illustrated in Table 9-1**.** Indirect construction costs include markups for taxes, permits, bonds, insurance, contractor's general conditions, overhead and profit, engineering services during design and construction, administrative costs, and contingency. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period. Development of costs is explained in greater detail in Section 9. A detailed life cycle cost analysis for the individual facilities is included in Appendix C.

Table 17-8 Summary of Capital and O&M Costs for Alternative 3+4-3 (McAlpine Creek WWMF Thermal Hydrolysis & Drying with Irwin Creek WWTP Pumping)

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
McAlpine Creek WWMF Direct Construction Costs	$31.58	$19.93	$51.50
Irwin Creek WWTP Direct Construction Costs	$3.96	$5.61	$9.57
Mallard Creek WRF Direct Construction Costs	**$3.38**	**$1.72**	**$5.10**
McDowell Creek WRF Direct Construction Costs	$1.50	$4.47	$5.97
Subtotal Direct Construction Costs	**$40.42**	**$31.73**	**$72.15**
Subtotal Indirect Construction Costs			**$53.37**
Total Capital Cost			**$125.52**
O&M Cost			**20-Year NPV ($M)**
Pre-Dewatering			$48.05
Pre-Treatment			$15.55
WAS Thickening			$13.19
Anaerobic Digestion			$5.52
Electrical Lysis			$10.41
Dewatering			$26.19
Thermal Drying			$33.16
Land Application			$23.41
Total Net Present O&M Cost			$175.47
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			$301.00

17.4.2 Alternative 3+4-3 Greenhouse Gas Emissions Offset

The annual lifecycle greenhouse gas (GHG) emissions associated with this alternative are presented in **Table 17-9**. Section 9.3.3 presents background information regarding greenhouses gas emissions and the model that was used to prepare the GHG emissions offset values.

Table 17-9 Greenhouse Gas Emissions for Alternative 3-7

Wastewater Treatment Facility	Metric Tons CO2 Equivalents per Year
McAlpine Creek WWMF	9,000
Irwin Creek WWTP	(800)
Mallard Creek WRF	(1,300)
McDowell Creek WRF	(80)
Total	**6,820**

Section 18

Third Party Contracting

18.1 General Considerations

Third party contracting has been an integral part of CMUD's biosolids management strategy. In 1999, CMUD contracted with Synagro (then BioGro) to manage the processed biosolids. This contract has approached the end of the contracting period. CMUD has the option to renew this for another 5 years. For municipalities managing biosolids via land application, it is very common to contract with a private service provider for the permitting, transportation, and land application operation.

The industry has also seen the use of public private partnerships (PPP) to design, construct, and operate major solids processing facilities. Often times this also involves financing. The benefits of the PPP approach include the availability of private funding which may otherwise be not available, the use of private, more specialized staff to operate often more complex technologies and facilities that plant operators may not be accustomed to, and the ability to implement changes to the biosolids program in a much faster manner. The most common use of this approach is for thermal drying facilities. The Massachusetts Water Resources Authority (MWRA), Greater Lawrence Sanitary District, the Philadelphia Water Department, the Metropolitan Water Reclamation District of Chicago, are all examples of utilities employing the PPP approach to construct thermal drying facilities for biosolids treatment. On the other hand, there are also many thermal drying facilities that are owned and operated by the utilities. Good examples in North Carolina are Cary and Winston-Salem. Both have constructed and are successfully operating thermal drying facilities for some time.

For the recommended biosolids management strategy, CMUD can certainly consider the PPP approach in implementation, especially regarding the drying process at McAlpine Creek WWMF. Since the drying process is at the end of the process train, it can easily be implemented and allow for third party contract operation without many impacts to the current plant operation. For the other processes such as thermal hydrolysis, having a third party operation may be more challenging as it is located much further upstream of the process unless plant operation is comfortable to contract the entire solids processing operation out.

Depending on the implementation plan, CMUD can consider the pros and cons of third party contracting. It is anticipated that at least part of the new management strategy tasks will be contracted out. For example, CMUD may not be interested in the actual marketing and distribution of the end products as this extends into more non-traditional areas that a utility will venture into. However, CMUD may elect to "do it all", providing it can commit the staff and management requirements. The ultimate decision will lie in the details of the implementation plan and how it matches the capital improvement plans as laid out.

Section 19

Comparison of WWTP Biosolids Management Alternatives

19.1 Overview

This Section compares the WWTP alternatives presented in Sections 14 through 17 based on both cost and qualitative evaluations.

- The cost comparison summarizes the life cycle costs combining opinion of probable construction cost with present worth O&M costs for each alternative.
- The qualitative analysis ranks each alternative based on the criteria discussed in Section 9.

19.2 Cost Evaluation

Table 19-1 summarizes the opinion of probable construction cost, 20-year O&M cost and greenhouse gas (GHG) impact of the WWTP alternatives. These costs were developed and presented in Sections 14 through 17. The greenhouse gas impacts are represented in units of metric tons of CO_2 equivalents (eq) per year (described in greater detail in Section 9) according to the net effect of addition or sequestration (offset) of greenhouse gases to/from the atmosphere as represented by

19.2.1 Opinion of Probable Construction Cost

The following capital cost range is identified in Table 19-1:

- Alternatives 3+4-1, 3+4-2, 3+4-3 ($112 M - $125 M): As expected, the alternatives combining thermal hydrolysis and thermal drying at McAlpine have the highest capital cost due to their technical complexity.
- Alternatives 3-8, 4-12 ($105 M - $110 M): These alternatives include thermal drying at McAlpine coupled with solar drying at McDowell, and thermal hydrolysis at McAlpine with electrical lysis elsewhere. Both scenarios require costly improvements that position them in the mid cost range for capital improvements.
- Alternatives 3-4, 3-6, 4-4 ($90 M - $100 M): These alternatives require significant capital improvements at McAlpine, consisting of thermal hydrolysis (with and without additional solids from Irwin) and thermal drying. However, no change in operations is planned at the other facilities, reducing the overall capital cost with respect to the options discussed above
- Alternatives 1-1, 3-7 ($50 M - $80 M): Maintaining current operations is associated to the lowest capital cost, followed by implementation of electrical lysis at all facilities.

Table 19-1 Life Cycle Cost Comparison of WWTP Alternatives

Alternative	1-1 Maintain Current Operations	3-4 McAlpine Thermal Hydrolysis	3-6 McAlpine Thermal Hydrolysis & Irwin Pumping	3-7 Electrical Lysis at all WWTPs	3-8 McAlpine Thermal Hydrolysis & Electrical Lysis at Other WWTPs	4-4 McAlpine Thermal Drying	4-12 McAlpine Thermal Drying & McDowell Solar Drying	3+4-1 McAlpine Thermal Hydrolysis & Drying	3+4-2 McAlpine Thermal Hydrolysis & Drying with Irwin Pumping	3+4-3 McAlpine Thermal Hydrolysis & Drying with Electrical Lysis at Other WWTPs
Capital Cost ($M)	$50.88	$93.92	$98.92	$76.94	$106.64	$96.65	$107.99	$112.80	$117.75	$125.52
O&M Cost for Treatment ($ M)	$77.89	$109.64	$115.72	$86.20	$118.89	$143.29	$146.91	$142.80	$166.27	$152.05
O&M Cost for Disposal ($ M)	$55.65	$49.42	$47.87	$59.20	$55.16	$17.68	$12.85	$17.68	$9.69	$23.41
20-Year NPV Total O&M Cost ($ M)	$133.54	$159.07	$163.59	$145.40	$174.06	$160.97	$159.76	$160.48	$176.25	$175.47
Total Life Cycle Cost ($ M)	$184.42	$253.00	$262.60	$222.40	$280.70	$257.62	$267.75	$273.30	$294.10	$301.00
Net GHG impact (Metric Tons CO2 eq/yr)	3,650	150	1,250	3,420	1,480	24,450	23,800	8,450	11,350	6,820

19.2.2 O&M Cost

Table 19-1 presents O&M costs for treatment unit processes and for disposal by land application, as well as their total cost.

- Alternatives 3-8, 3+4-2, 3+4-3 ($170 M - $180 M): Consistent with their complexity, these alternatives have the highest O&M cost. They include thermal hydrolysis (with or without thermal drying) at McAlpine, either treating solids from Irwin or providing electrical lysis at the other facilities. The treatment cost is higher than for other alternatives, while the disposal portion is lower than most other alternatives, as it is assumed that the disposal of the pelletized product at McAlpine is cost neutral (i.e., it will be distributed and marketed at no cost to O&M). The exception is Alternative 3-8, for which also the disposal cost remains high.
- Alternatives 3-4, 3-6, 4-4, 4-12, 3+4-1 ($155 M - $165 M): Thermal hydrolysis at McAlpine is the foundation of these strategies, either alone or combined with thermal drying. The other facilities either maintain current operations or use electrical lysis. In addition, Irwin can also phase out its facility and pump unprocessed sludge to McAlpine for treatment. While the overall O&M cost is comparable for all these alternatives, the disposal cost is lower for the options that use thermal drying and do not have to land apply the solids, which is assumed will be distributed and marketed
- Alternatives 1-1, 3-7 ($130 M - $145 M): Maintaining current operations and electrical lysis at all facilities incurs the lower O&M cost.

19.3 Qualitative Evaluation

The foundation of the qualitative analysis consists of the development and weighting of the evaluation criteria presented in Section 9. The weights associated to each criterion define the relative relevance of that criterion and were established by CMUD staff. The rating of the individual alternatives with respect to each criterion were developed by CDM Smith and further discussed with CMUD staff at Workshop 4.

Table 19-2 summarizes the weights for the criteria and the ratings for each alternative. As discussed in Section 9, the alternatives were ranked based on their overall assessment, which was normalized on a 0-1 scale, 1 being the best possible score. **Figure 19-1** presents the final results. The considerations in **Table 19-3** contributed to establishing the ratings associated to each alternative

Alternative 3+4-2 received the highest score, due to the following factors:

- Ability to provide flexible and multiple outlets for Class A biosolids.
- Substantial reduction in volume of the final product.
- Potential for distribution and marketing.
- Reliable and consistent performance.
- Best management strategy from a public perception and acceptance perspective.

Table 19-2 Alternatives Evaluation Criteria Rating and Score

Evaluation Criteria (Weight)	1-1 Maintain Current Operations	3-4 McAlpine Thermal Hydrolysis	3-6 McAlpine Thermal Hydrolysis & Irwin Pumping	3-7 Electrical Lysis at all WWTPs	3-8 McAlpine Thermal Hydrolysis & Electrical Lysis at Other WWTPs	4-4 McAlpine Thermal Drying	4-12 McAlpine Thermal Drying & McDowell Solar Drying	3+4-1 McAlpine Thermal Hydrolysis & Drying	3+4-2 McAlpine Thermal Hydrolysis & Drying with Irwin Pumping	3+4-3 McAlpine Thermal Hydrolysis & Drying with Electrical Lysis at Other WWTPs
Long Term Sustainability (5)	1	7	7	2	6	7	7	8	10	9
Reliability (5)	2	6	7	3	5	7	7	8	9	6
O&M Cost (5)	10	5	3	8	1	4	4	4	1	1
Process Maintainability (4.5)	8	5	7	8	5	4	4	3	6	2
Impact on Existing Facilities (4)	9	4	5	8	4	6	6	3	4	2
Operability/Ease of use (3.5)	8	4	6	7	4	4	4	3	2	2
Partnership and Regionalization (1)	1	4	8	1	4	4	4	4	8	4
Capital Cost (1)	10	5	4	7	3	4	3	2	2	1
Resource Recovery Opportunities (2)	3	7	7	6	8	7	8	9	9	10
Risk Management (3)	1	6	5	3	7	7	8	9	8	10
Flexibility/Adaptability (2)	1	6	6	2	7	6	7	9	9	10
Public Perception/Acceptance (2)	1	6	7	2	7	7	8	9	10	9
Side Stream Impacts (3)	8	4	4	6	4	6	6	4	4	1
Proven Technology (3.5)	9	6	6	4	5	8	7	7	7	7
Normalized Score	**0.566**	**0.543**	**0.575**	**0.523**	**0.472**	**0.590**	**0.598**	**0.582**	**0.615**	**0.493**
Alternatives Rank (1.0 Is the Best Score)	**6**	**7**	**5**	**8**	**10**	**3**	**2**	**4**	**1**	**9**

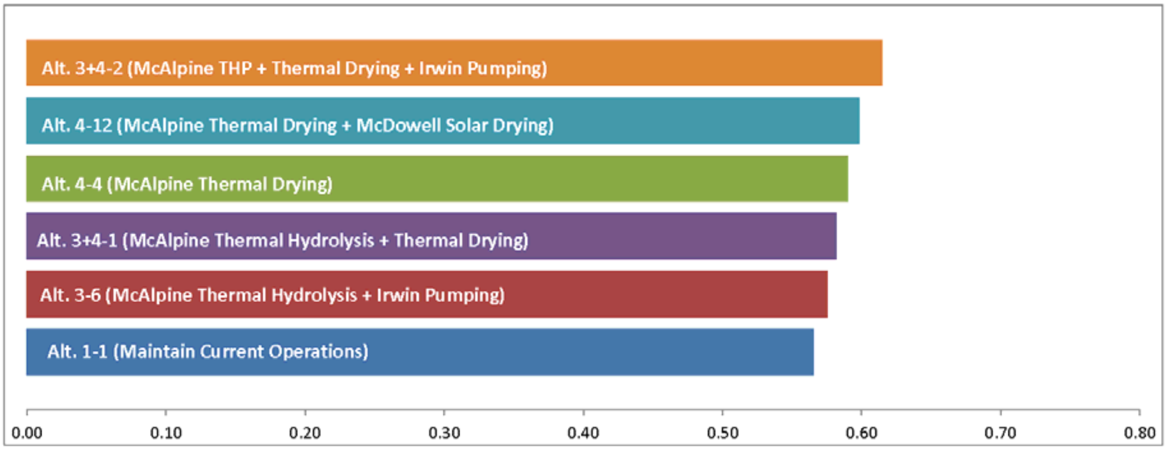

Figure 19-1
Alternative Scores

Table 19-3 Rating Considerations for Alternatives Evaluation Criteria

Criteria (Weight)	Description/Rating General Comments
Long Term Viability/ Sustainability (5)	*Long-term viability is defined as the ability to meet the biosolids and residuals handling, treatment, and disposal/end use requirements throughout the planning period. This includes identifying technologies that are durable and are capable of meeting anticipated regulatory changes, ensuring that there is a sustainable market for the biosolids end product, and quantifying potential changes in energy costs that may impact treatment options, etc.*
	Thermal hydrolysis and thermal drying received high ratings due to the ability to provide multiple outlets and meet future, more stringent regulations. Treating solids from Irwin at McAlpine was also a positive factor. Combining thermal hydrolysis with thermal drying further improves the ability of McAlpine to become a more sustainable operation in the future. Maintaining current operations received the lowest rating as it will not enable CMUD to differentiate their current Class B limited disposal options.
Reliability (5)	*Ability of a given treatment process to consistently perform in accordance with the intended design and function of the system with minimal down time. A reliable system aims at optimizing its performance. Systems that require extensive equipment may be considered less reliable than other less equipment or chemical dependent systems.*
	Thermal drying is an established technology that performs reliably. Thermal hydrolysis is emerging as a process that performs consistently achieving Class A and improved dewatering capabilities. The combination of the two would enhance the process and would allow ensuring delivery of a Class A pelletized final product. The current operations are seen as unreliable due to the ongoing issues with the dewatering process at McAlpine.
O & M Cost (5)	*Operation and maintenance costs compared to current practices. Includes energy consumption required for process.*
	O&M costs are impacted by the complexity of thermal drying and thermal hydrolysis, and the use of natural gas. However, the reduced volume of solids translates into less disposal costs, as further discussed in this Section
Process Maintainability (4.5)	*The ease in which a treatment process is maintained. Accessibility of equipment, required spare parts inventory, availability of parts, and special tools or skill requirements are associated with the maintainability of a treatment system.*
	Maintenance of operations received a high rating as it is relatively easy and proven, while thermal hydrolysis and drying require significant monitoring and control of operations, and therefore received lower ratings. Pumping sludge from Irwin increased the rating as it is associated to phasing out the facilities at this Irwin.
Impact on Existing Facilities (4)	*Potential impacts on existing processes, including potential for air quality/odor impacts during processing.*
	The impact on existing facilities is high with thermal hydrolysis, relatively modest with the addition of thermal drying and minimum with maintenance of current operations.
Proven Technology (3.5)	*This criterion relates to utilizing technologies with a proven history of success. This includes technology that may not yet be widely utilized in the US but have a proven history of success worldwide.*
	With the exception of electrical lysis which is an innovative technology, all other processes are established. Thermal drying has been used successfully for decades at several facilities. Thermal hydrolysis is rapidly becoming a proven technology that performs well at various facilities overseas.

Criteria (Weight)	Description/Rating General Comments
Operability/ Ease of Use (3.5)	*The ease of operation of a treatment system. The amount and type of operator attention and the degree of automation are both aspects of the operability of a treatment system. Some alternatives may require a high degree of control for efficient operation, while others may require less.*
	The more complex technologies received lower ratings as they are more difficult to operate.
Risk Management (3)	*This criterion relates to how much risk is associated with a given alternative and the degree to which the risk can be managed (i.e., is the market for the product end use guaranteed, are all cost impacts (current and future) fully understood and captured, etc.)*
	Risk management is offset by the installation of Class A technologies such as thermal hydrolysis and drying, and is further mitigated by the combination of the two. Maintaining current operations may become a critical asset with increased public awareness and limited options for disposal of Class B biosolids.
Side Stream Impacts (3)	*Some of the biosolids management technologies (such as anaerobic digestion technologies) can generate return flows that have high concentrations of ammonia and phosphorous. This high nutrient loading may upset the liquid treatment and may result in high levels of nitrogen and phosphorous in the effluent. However, while the sidestream associated to dewatering is a challenge, it is also an opportunity for nutrient recovery. Once the nutrients are out of the solids stream, they are easier to recover.*
	Thermal hydrolysis generates the elevated phosphorus levels downstream of digestion and therefore had the lowest rating. Note however that implementation of a phosphorus removal system allows to recover the nutrients and market them. Maintenance of current operations scored high as it is associated to the lowest levels of nutrients being produced in the dewatering process.
Public Perception/ Acceptance (2)	*This criterion includes the positive or negative impact each alternative has on the surrounding community including residents and businesses near the WWTP and at biosolids land application locations. Public acceptance includes environmental, aesthetic, and ergonomic factors such as traffic, noise, odor, and visual appeal.*
	Public awareness of issues associated to land application of Class B biosolids has grown over time and therefore all options associated to production of Class A biosolids were given high ratings. The combination of thermal hydrolysis and drying at McAlpine, coupled with the reduction in operations at Irwin, received the highest rating as it would substantially decrease the level of solids generated and operations at Irwin.
Flexibility/ Adaptability (2)	*Ability of a proposed alternative to accommodate the varying conditions of flow, waste load, maintenance service needs, etc., and still meet regulatory permit requirements and being able to adapt based on current conditions. Some alternatives may require major additional capital expenditures that hinder cost-effective improvements should permit conditions or other factors such as flows and loadings to the facilities change.*
	The more complex options received the highest ratings as they provide multiple outlets for the final product which would be Class A and marketable.

Criteria (Weight)	Description/Rating General Comments
Resource Recovery Opportunities (2)	*Optimization of all potential resource recovery opportunities can contribute to a successful policy for disposal of the final product.*
	Thermal hydrolysis coupled with thermal drying provides the greatest opportunity to market the final product and reduce sidestreams by means of recovery of elevated phosphorus levels. The other options involving thermal hydrolysis and drying also score high.
Partnerships and Regionalization (1)	*Ability to create a regional facility with the intent to incur several benefits, such as reduced capital cost by providing a single facility, single location for collection of end product, more cost effective and simpler O&M, holistic approach to biosolids treatment and disposal.*
	The highest ratings were received by the alternatives that plan on processing the Irwin sludge at McAlpine. Achieving Class A with thermal hydrolysis and drying is also seen as a potential incentive for other municipalities to treat their sludge at McAlpine in the future.
Capital Cost (1)	*Opinion of Probable Construction Cost in year 2013 dollars.*
	The construction cost associated to thermal hydrolysis and drying is substantial, and therefore these alternatives scored low ratings, while maintenance of current operations received the highest rating, as expected.

Section 20

Recommended Capital Improvement Plan

20.1 WWTP Biosolids Recommended Facilities

Based on the evaluation presented in Section 19, Alternative 3+4-2 is the recommended WWTP biosolids alternative, due to its alignment with CMUD's goals, taking into account potential risk and the degree of operational flexibility it affords. The development of this recommendation takes into account trends in biosolids and residuals management strategies employed by other large facilities located in the South Eastern United States and around the nation (detailed in **Appendix G**).

This alternative implements thermal hydrolysis coupled with thermal drying at McAlpine Creek WWMF which would also receive and process primary and waste activated sludge pumped from the Irwin Creek WWTP as well as Sugar Creek WWTP. The Mallard Creek WRF and McDowell Creek WRF would continue to maintain current operations. The following summarizes the proposed capital projects associated with this recommended alternative.

- **McAlpine Creek WWMF Thermal Hydrolysis Coupled with Anaerobic Digestion and Thermal Drying**

  At McAlpine Creek WWMF, the process flow train will include blending of WAS and primary solids, screening, pre-dewatering followed by thermal hydrolysis, anaerobic digestion and final dewatering. The stabilized biosolids will then be fed to a thermal dryer consisting of a rotary drum dryer producing a pelletized Class A material ready for distribution and marketing. A process flow diagram is shown in **Figure 20-1**.

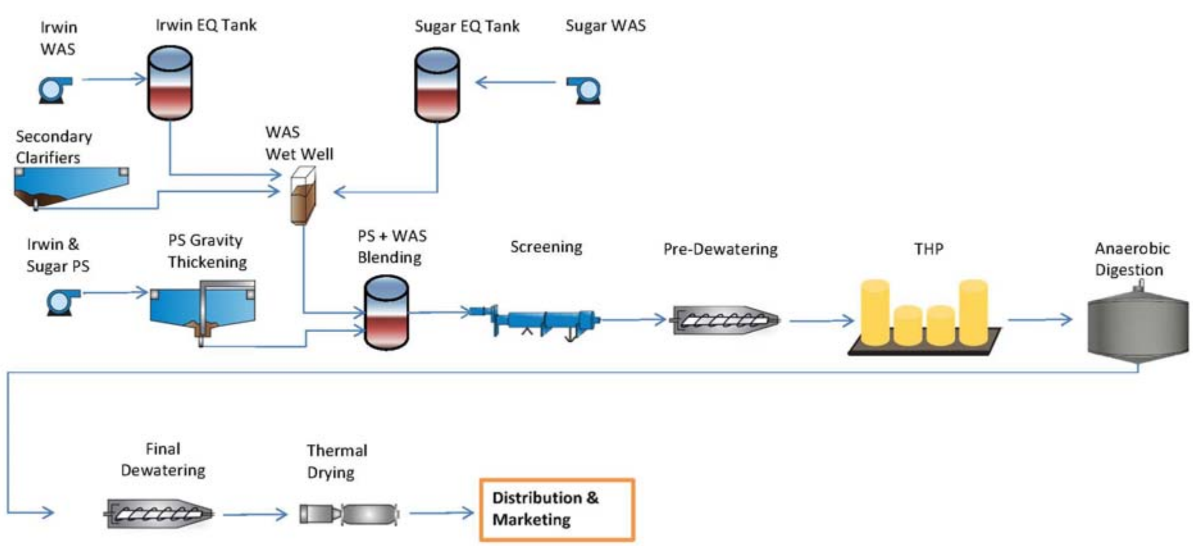

Figure 20-1
Recommended Alternative – McAlpine Creek WWMF Process Flow Diagram

- ***Thermal Hydrolysis*** **-** Prior to anaerobic digestion, sludge is fed through a thermal hydrolysis process in which the reactors are heated with steam to 320 °F and pressurized to 100 psi, achieving pathogen reduction and biomass cell lysis. Following hydrolysis, sludge is diluted with effluent water and is fed to anaerobic digesters. Thermal hydrolysis offers several benefits including:

    - Increased digester solids loading at 10 to 11 percent solids.
    - Higher VSR, estimated at 60 percent, resulting in fewer residual solids and greater biogas production.
    - Improved dewatering performance with drier cake at 30 percent solids
    - Class A product, no fecal regrowth issues.
    - Odorless product.

- ***Thermal Drying*** – Rotary drum dryers are the prevalent type of dryer currently in use in the U.S. at medium to large facilities, and are proposed for evaluation at McAlpine Creek WWMF. Rotary drum dryers represent a direct drying process, in which the heated air comes in direct contact with the biosolids in the rotating drum, evaporates water and produces a dry hard pellet with solids content above 90 percent. A single dryer with the ability to evaporate 5 metric tons per hour of moisture from the dewatered solids is proposed for this scenario. The pellets are stored in silos integral to the drying facility, and exhaust gases are treated to remove odor causing compounds and particulates. Fuel for heat drying may be natural gas or biogas.

  The dried material meets Class A biosolids requirements for pathogen reduction and has a significantly reduced volume, which facilitates transportation to more distant markets. It is also suitable for distribution and marketing as a fertilizer or soil conditioner, instead of being land applied.

- **Irwin Creek WWTP Sludge Transfer to McAlpine Creek WWMF**

  - Unthickened primary solids and WAS will be pumped to McAlpine Creek WWMF from Irwin Creek WWTP for processing and handling. Two new pump stations (one for primary sludge and one for WAS) dedicated to each solids stream will be constructed at Irwin Creek WWTP, and will convey the liquid unstabilized sludge to McAlpine Creek WWMF through separate force mains.

    Each pump station will consist of a two new submersible wastewater pumps with an estimated capacity of 250 gpm each, located in existing tanks (e.g., existing digesters) reconditioned for this new function. A force main will transfer primary solids to the gravity thickeners at McAlpine Creek WWMF through a new six inch ductile iron force main. The new pipe would run along the same route where an existing sewer line is already installed for an approximate distance of 13.5 miles. A second similar pump station will deliver WAS through a separate 6-inch force main to the a new 31,000 gallon equalization tank at McAlpine Creek WWMF, prior to discharge to the existing WAS wet well, where it would blend with WAS from McAlpine Creek WWMF and Sugar Creek WWTP.

The existing biosolids treatment facilities at Irwin Creek WWTP will be phased out once construction of the pipelines/force mains and Thermal Hydrolysis at McAlpine Creek WWMF is complete. The Dewatered Cake Storage Facility will continue to be used for storage of residuals transported from Vest and Franklin WTPs until the new storage facility at Franklin WTP is complete.

- **Mallard Creek WRF & McDowell Creek WRF Maintain Current Operations**

  - Mallard Creek WRF and McDowell Creek WRF would continue to maintain current operations with mesophilic anaerobic digestion. Primary solids and thickened WAS are sent to the digesters, which are maintained at a temperature of approximately 95 °F, assuming a minimum solids retention time (SRT) of 17 days at two week max solids loading rates. It is possible that in the future digestion will experience a reduction in volatile solids reduction (VSR), due to increased solids loadings. While VSR values up to 60 percent have been measured in the past, it has been assumed that the future VSR could decrease to 50 percent.

- **Other Recommended Improvements**

  In addition to the facility requirements identified above, the following is a summary of the capital improvements recommended for the WWTPs to remain in operation for the duration of the planning period.

  - ***McAlpine Creek WWMF - New Sugar Creek WWTP Equalization Tank***: The existing WAS wet well has a capacity of 90,000 gal. According to CMUD staff it represents a bottleneck and impacts thickening operations. One new 31,000 gal above-grade tank is proposed to receive the WAS pumped from Sugar Creek WWTP. Another similar tank will be provided for the WAS from Irwin Creek WWTP. From these two tanks, the equalized flow will be discharged to the existing wet well, where it is mixed with WAS from McAlpine Creek WWMF.

  - ***McAlpine Creek WWMF - Phosphorus Recovery***: A phosphorus recovery system similar to two Pearl reactors by Ostara is recommended to avoid chemicals purchase and sludge disposal costs, in addition to taking advantage of potential revenues from fertilizer sales.

    McAlpine Creek WWMF - Dewatering Centrifuges: It is estimated that one dewatering centrifuge will be required for the planning period if operated continuously. While a second centrifuge is currently available to provide standby capabilities, it is recommended that a third unit be provided as it will allow increased flexibility and reliability during operations. This unit would also be installed in the Thickening/Dewatering Building.

  - ***Mallard Creek WRF - Thickening/Dewatering Upgrade***: The diaphragm pumps used to discharge thickened WAS to the digesters require significant maintenance for operation and are prone to clogging. Further, pumping solids above four percent requires dilution of the sludge. It is recommended that these units be replaced with pumps that are suitable for high solids concentrations and are less maintenance intensive, such as progressing cavity pumps. This capital project includes the replacement of three units with 100 gpm progressing cavity pumps.

    Mallard Creek WRF is currently equipped with two thickening centrifuges having different performance from each other. In order to process future solids projections, the smaller unit will be replaced with a larger thickening centrifuge with a capacity of 800 lb/hr at 0.65 percent solids. Similarly, the smaller dewatering centrifuge would be replaced with a larger unit with a capacity of 2,400 lb/hr at 1.9 percent solids. This improvement would allow operating a single thickening and dewatering unit for the entire planning period, leaving the other unit on standby. Based upon preliminary sizing, it is anticipated that the two larger centrifuges will fit in the existing building. However, given the limited space available, this will need to be confirmed during design. While the proposed new thickening centrifuge has dimensions similar to the existing larger unit, the new proposed dewatering centrifuge is substantially larger, making this installation tight in the current space allocated for these units.

- ***Mallard Creek WRF - Biogas Conditioning System***: Mallard Creek WRF is the only facility operated by CMUD that is not equipped with a biogas scrubbing system, which has led to corrosion issues in the gas handling system. The proposed biogas conditioning system includes sulfur removal and a gas compression/moisture system equipped with a gas blower and a dual core heat exchanger to remove moisture, large particulate and liquid droplets.

- ***McDowell Creek WRF - Dewatered Biosolids Storage Facility***: A new facility will be required to provide 120 days of storage up to year 2035. It is anticipated that the new facility would be 300 feet in length by 130 feet in width and would be located north of the existing facility. The new facility would consist of a covered concrete pad similar to the existing storage facilities. Trucks would transfer dewatered cake to the storage area, where the biosolids would be deposited. A front-end loader would then be used to move the cake into piles. The same equipment would be used to load trucks with residuals for transport to end use.

20.2 WTP Residuals Recommended Facilities

Based on the recommendation outlined in Section 13, Alternative 11-1 is the recommended WTP residuals alternative. This alternative completely separates the disposal of WTP residuals from WWTP biosolids and reduces the number of sludge hauling trucks by pumping residuals from Vest to Franklin. The following summarizes the proposed capital projects associated with this recommended alternative.

Franklin Dewatered Cake Storage: Instead of hauling dewatered cake to Irwin Creek WWTP, a new Dewatered Solids Storage Facility would be located southeast of the dewatering building at Franklin. The new facility would consist of a covered concrete pad and would be 220 feet in length by 150 feet in width. Trucks would transfer dewatered cake to the storage area from the Dewatering Building. A front-end loader would then be used to move the cake into piles. The same equipment would be used to load trucks with residuals for transport to end use.

Vest Pumping Facilities: It is recommended that the residuals from Vest be pumped at low solids concentrations (less than 1 percent) to Franklin through a 4-inch new force main. The preliminary pipe route is estimated to be 2.7 miles long. A routing study should be performed to optimize the proposed alignment.

Two submersible wastewater pumps (including one standby unit) with a minimum capacity of 100 gpm are required to transfer the residuals to Franklin. The same arrangement used for the three units currently installed in the Backwash Water Mixing Basin would be maintained, and it is possible that the existing pumps may continue to be used for this future application. This will be further evaluated during design, once the alignment for the force main if determined.

Lee S. Dukes Dewatering and Storage Facility: The solids from the lagoon are currently pumped on vacuum trucks and land applied. One 2-meter BFP is proposed to dewater the solids to a cake solids concentration of 25 percent. In order to dewater year 2035 solids, it would be necessary to operate the BFP for 3 days per week, six hours per day (total of 18 hours per week). A 12,000 gal holding tank is proposed for temporary storage of the liquid residuals pumped out from the lagoon.

It is proposed that the 2-meter BFP will be housed in a new dewatering building located south-east of the lagoon. As the solids are dewatered, cake will drop out of the belt filter press onto a belt conveyor. The end of the belt will be positioned over the top of a drive-through area for trucks.

A new Dewatered Solids Storage Facility is proposed to be constructed in the vicinity of the proposed dewatering building. The new facility would consist of a covered concrete pad and would measure approximately 80 feet in length by 70 feet in width. Trucks would transfer dewatered cake to the storage area from the Dewatering Building. A front-end loader would then be used to move the cake into piles. The same equipment would be used to load trucks with residuals for transport to end use.

This facility would have a capacity of approximately 400 wet tons, corresponding to storage of the average residuals production projected for year 2035 for 90 days.

20.3 Phasing and Implementation Schedule

Phased implementation of the facilities proposed is recommended as a means of rendering the large capital cost more compatible with CMUD's budget while still meeting the goals of the master plan. This evaluation does not account for replacement of equipment approaching its end of life.

Biosolids Implementation Strategy: **Figure 20-2** is a graphical representation of the recommended implementation schedule/strategy. The strategy consists of phasing in different actions in order to achieve systematic improvements to the biosolids program. In the first phase of the program CMUD should focus on beginning a public information program to help the public understand the commitment that CMUD is making to the environment by embarking on this program. Concurrently, CMUD should begin the implementation of the first major capital projects being recommended including construction of a thermal hydrolysis process and McAlpine as well as constructing the pipelines to transfer solids from Irwin to McAlpine. Some of the benefits that will be seen by implementing these Phase I actions include addressing the fecal regrowth/odor issues, reduction of biosolids total volume, providing for regionalization of treatment, diversification of biosolids end uses and increasing the public awareness regarding the benefits of producing a Class A biosolids.

During Phase II of the program CMUD should reassess the environmental, regulatory and socio-economic issues regarding the implementation of this program. CMUD should consider the pros and cons regarding third party contracting and either renew or issue an RFP for third party land application. Phase II should also include the implementation of last of the major capital projects including the thermal dryer. Once the thermal dryer is constructed the complete benefits of the biosolids program will be seen. These benefits include a significant diversification of potential end uses for the biosolids including Class A and Class B land application, soil blending, fertilizer blenders, utilizing 3rd party brokers for marketing and distribution of the pellets as well as CMUD operating as a broker for uses at golf courses, sod farms and numerous other operations.

<u>WTP Residuals Implementation Strategy</u>: The main strategies associated with the implementation of the WTP residuals is the complete separation from the wastewater biosolids program. Some of the benefits of separating from the biosolids program include allowing for a less stringently regulated disposal of WTP residuals. WTP residuals can be treated similarly to a Class A material thereby allowing for greater flexibility in the ultimate disposal of the residuals.

2013 → 2018 → 2023 → 2035

2013 – 2018

ACTIONS
- Public Information Program
- Implement THP at McAlpine
- Renew Synagro contract or issue new RFP
- Evaluate dryer procurement options
- Expand NC land base
- Continue to evaluate current and emerging marketplace for end users
- Vest residuals to Franklin
- Manage WTP residuals separately from WWTP biosolids
- Irwin biosolids to McAlpine

PRODUCT END-USES
- Class B Land application
- Landfill

BENEFITS
- Address fecal regrowth/odor issues
- Increases digestion capacity
- Opportunities for regionalization
- Improved dewaterability
- Increased public acceptance and awareness
- Diversification of end uses
- Increased biogas production

2018 – 2023

ACTIONS
- Re-evaluate strategy and implementation plan
- Implement dryer at McAlpine
- Renew or issue RFP for land application

PRODUCT END-USES
- Landfill
- Class A and B cake land application
- Landfill cover
- Soil blending

BENEFITS
- Further diversification of end use
- Significant product quality improvement
- Significant reduction of product volume (20 - 30%)

2023 – 2035

ACTIONS
- Re-evaluate strategy and implementation plan
- Further develop end use options

PRODUCT END-USES
- Landfill
- Class A and B cake land application
- Landfill cover
- Soil blending
- Fertilizer blenders
- 3rd party pellet brokers
- CMUD Broker
  - Parks and Recreation
  - Golf Courses
  - Sod & Turf Farms
- Fuel source
  - Cement kiln
  - Brick kiln
  - Furnaces

Figure 20-2
Implementation Strategy

As seen in Figure 20-2, the strategies set forth in this master plan should be re-evaluated at least every five years to assess any changes in the regulatory area or other environmental or economic changes that may influence the program.

Irwin Creek WWTP Sludge Transfer to McAlpine Creek WWMF – Avoided Costs: Prior to the recommendations in this master plan, CMUD has designed improvements to the dewatering facility at Irwin Creek WWTP including the installation of two new belt filter presses under the existing sludge storage facilities, new sludge transfer pump station, and new polymer storage and feed system with an estimated cost of approximately $2 M. Additionally, plans have been developed for a new dewatering building with a capital cost of approximately $4.5M.

As detailed in the master plan, it is recommended that unthickened primary solids and WAS be pumped to McAlpine Creek WWMF from Irwin Creek WWTP for processing and handling and that all treatment of biosolids at Irwin Creek WWTP be abandoned. In an effort to avoid the capital costs associated with dewatering improvements at Irwin Creek WWTP, it is recommended that the WAS and primary solids force mains be constructed as early as possible. It is recommended that these facilities be installed to initially transfer *anaerobically digested* biosolids from Irwin Creek WWTP to McAlpine Creek WWMF for dewatering. McAlpine Creek WWMF does not currently have the capacity in the anaerobic digesters to treat all of the unstabilized biosolids from Irwin Creek WWTP, however McAlpine Creek WWMF does have the capacity to dewater all of Irwin Creek WWTP's stabilized biosolids.

Once the THP project has been implemented (recommended completion in FY 18) then changes may be made to transfer unthickened primary solids and WAS from Irwin Creek WWTP to McAlpine Creek WWMF for stabilization. This is possible since the THP project will enable much greater capacity in the anaerobic digesters to treat additional biosolids.

Table 20-1 presents the recommended Biosolids and Residuals Master Plan implementation schedule.

Table 20-1 CMUD Biosolids & Residuals Master Plan Implementation Schedule

Capital Project	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
WWTP Biosolids Improvement Projects												
Thermal Hydrolosis System at McAlpine												
Facilities Plan	$ 400,000											
Engineering		$ 3,650,000	$ 1,830,000	$ 1,830,000								
Construction			$ 24,700,000	$ 24,700,000								
PS & WAS Pipelines from Irwin to McAlpine												
Engineering		$ 900,000	$ 450,000	$ 450,000								
Construction			$ 6,030,000	$ 6,030,000								
Sugar & Irwin WAS Equalization Tanks at McAlpine												
Engineering		$ 65,000	$ 65,000									
Construction			$ 880,000									
Gas Conditioning System at Mallard												
Engineering			$ 85,000	$ 85,000								
Construction				$ 1,130,000								
Phosphorus Recovery at McAlpine												
Engineering				$ 385,000	$ 385,000							
Construction					$ 5,140,000							
Dewatering Complex Upgrade at McAlpine												
Engineering						$ 220,000	$ 220,000					
Construction							$ 2,970,000					
Thermal Dryer at McAlpine												
Engineering								$ 1,630,000	$ 810,000	$ 810,000		
Construction									$ 10,860,000	$ 10,860,000		
Thickening/Dewatering Improvements at Mallard												
Engineering											$ 250,000	$ 250,000
Construction												$ 3,330,000
Dewatered Residuals Storage Facility at McDowell												
Engineering											$ 380,000	$ 380,000
Construction												$ 5,170,000
WTP Residuals Improvement Projects												
Vest FM & Pump Station to Franklin												
Engineering			$ 150,000	$ 150,000								
Construction				$ 2,030,000								
Franklin Dewatered Residuals Storage Facility												
Engineering			$ 330,000	$ 330,000								
Construction				$ 4,470,000								
Duke Dewatering Building and Residuals Storage Facility												
Engineering					$ 230,000	$ 120,000	$ 120,000					
Construction						$ 1,560,000	$ 1,560,000					
Totals by FY:	$ 400,000	$ 4,615,000	$ 34,520,000	$ 41,590,000	$ 5,755,000	$ 1,900,000	$ 4,870,000	$ 1,630,000	$ 11,670,000	$ 11,670,000	$ 630,000	$ 9,130,000

Appendix A

Residuals Processing Facilities and Equipment Evaluation

Franklin WTP Residuals Processing Facilities and Equipment

Sedimentation Basins			
No. Modules	1	1	1
No. Basins	6	6	8
Module Capacity, each, MGD	36	24	72
Residual Collection System	Chain and flight with manually operated mud valves	Chain and flight with telescoping valves	Super Scraper with telescoping valves
Filters			
No. Modules	1	1	1
No. Filters	12	4	6
Backwash Water Lagoons			
Quantity	2		
Total Volume, each, gal	700,000		
Effective Volume, each, gal	436,000		
Length, each, ft	100		
Width, each, ft	100		
SWD, ft	10		
Submersible Mixers, No. per lagoon	8		
Backwash Clarifiers			
Quantity	1		1
Volume, each, gal	333,000		667,000
Diameter, ft	70		100
SWD, ft	12.5		12.5
Hydraulic loading (max/avg), each, gpm/sq.ft	0.4/0.13		0.4/0.29
Hydraulic loading (max/avg), each, gpm	1,540/250		3,200/1,000
Washwater throughput (max/avg), each, mgd	2.24/0.36		4.60/1.44
Backwash Residuals Pump Station			
No. pumps	3		
Type	submersible centrifugal		
Capacity, each, gpm	1,000		
Horsepower, each, hp	20		
Solids Concentration, percent	0.5		
Residuals Basin			
No. Basins	1		
Volume, each, gal	450,000		
Diameter, ft	85		

Sedimentation Basins		
SWD, ft	13.5	
High water level, elevation	785.50	
Capacity per foot, gal	42,500	
Residuals Basin - Mixers		
Unit ID	FRM-1,-2,-3	
Quantity	3	
Horsepower, each, hp	20.0	
Unthickened Residuals Pump Station		
No. pumps	2	
Type	non-clog, centrifugal	
Capacity, each, gpm	400	
Horsepower, each, hp	7.5	
Gravity Thickeners		
Quantity	1	1
Volume, each, gal	90,000	214,000
Diameter, ft	45	55
SWD, ft	12	12
Residual removal system	scraper	scraper
Solids loading rate, lb/hr/sqft	0.2	0.2
Hydraulic loading (max/avg), mgd, each	250/100	250/100
Thickened Residuals Pump Station		
No. pumps	2	
Type	progressing cavity	
Manufacturer/Model	Moyno	
Capacity, each, gpm	150	
Horsepower, each, hp	10	
Dewatering Belt Filter Press		
Quantity	3	
Size	2-m	
Hydraulic loading rate, each, gpm	130-265	
Feed solids concentration, %	2	
Polymer dose, lb/ton	6	
Solids recovery rate, %	95	
Cake solids concentration, %	23-26	
Cake density, lb/cft	70	
Washwater rate, gpm	85	
BFP horsepower, hp	15	
Washwater pump horsepower, hp	5	
Belt conveyor horsepower, hp	5	
Polymer feed system horsepower, hp	4	
Polymer Feed System		
Quantity	1	1
Unit ID	PFS-1	PFS-2

Sedimentation Basins		
Type	liquid anionic emulsion polymer, 225 gal totes	Liquid cationic emulsion polymer, 225 gal totes
Feed Blender Designation	Acrison FPTP-1	Acrison FPTP-2
Dedicated Mix Tanks	FPMT-1, -2	FPMT-3, -4
Capacity, gal	600	600
Emulsion Polymer Feed Pump		
Quantity	2	
Unit ID	FPTP-1	FPTP-2
Feed System Type	Positive displacement rotary lobe	Positive displacement rotary lobe
Feed Pump Type	Diaphragm	Magnetic head, centrifugal

Vest WTP Residuals Processing Facilities and Equipment

Sedimentation Basins	North	South
Unit ID	1 - 4	5 - 8
Quantity	4	4
Volume, each, gal	310,000	647,000
Length, each, ft	96	96
Width, each, ft	28	58
SWD, ft	16	16
Surface area, sq.ft	2,670	5,570
Sedimentation Basins Residuals Removal Equipment		
Vac-Trac collectors per Basin	3	2
Removal mechanism	pneumatic	pneumatic
Manufacturer	EIMCO	EIMCO
Removal rate, each, gpm	155	155
Removal solids concentration, %	0.2-0.5	0.2-0.5
Unthickened Residuals Pump Station		
No. pumps	3	
Type	Horizontal, non-clog, centrifugal	
Capacity, each, gpm	100	
Horsepower, each, hp	5	
Residuals Decant Tanks		
Quantity	2	
Volume, each, gal	90,000	
Size, each, ft	32 x 32 x 12	
Supernatant decant level, ft above floor	12	
Supernatant decant level, ft above floor	17	
Supernatant decant level, ft above floor	22	
Overflow decant level, ft above floor	24	
Thickened Residuals Pump Station		
No. pumps	2	
Type	Constant speed, self-priming	
Capacity, each, gpm	200	
Horsepower, each, hp	7.5	
Backwash Water Mixing Basin		
Quantity	1	
Usable volume, each, gal	350,000	
Diameter, ft	70	
SWD, ft	14	
Backwash Water Mixing Basin - Mixers		
Quantity	3	
Propeller diameter, in	12	
Propeller speed, rpm	385	
Manufacturer	Flygt	
Horsepower, each, hp	5	
Backwash Water Mixing Transfer Pump Station		
No. pumps	2	1
Type	submersible, centrifugal	submersible, centrifugal
Capacity, each, gpm	1,000	1,000

Sedimentation Basins	North	South
Horsepower, each, hp	15	10
Backwash Water Transfer Pump Station		
No. pumps	3	
Type	Submersible	
Capacity, each, gpm	1,000	
Horsepower, each, hp	30	
Polymer Feed System		
Polymer feed rate, dry lb/hr	0.4	
Solution concentration, %	0.2	
Solution feed rate, gph	23	
Filters		
Unit ID	1 - 6	7 - 12
Length, each, ft	40	56
Width, each, ft	12	17
Surface area, each, sq. ft	480	952
Media support and backwash distribution	Piatt Bottom	Wheeler bottom
Max backwash flow rate, mgd	1.5	11.5
Filter Backwash Return Pumps		
Quantity	1	
Type	submerged	
Horsepower, hp	50	

Lee S. Dukes WTP Residuals Processing Facilities and Equipment

Sedimentation Basins		
Unit ID	East Module 1	East Module 2
Sedimentation Basins Residuals Removal Equipment		
Type	Chain and flights	
Removal solids concentration, %	0.5% to 1.0%	
Sedimentation Basins Pump Station		
No. pumps	2	
Type	Horizontal centrifugal dry pit	
Filters		
No. Modules	East Module 1	East Module 2
EQ Basin Transfer Pumps		
Quantity	2	1
Type	Submersible centrifugal	Submersible centrifugal
Manufacturer/Model	Flygt / CP-3152 MT	Flygt / CP-3152 MT
Capacity, each, gpm	1,130	800
Horsepower, hp	20	20
EQ Basin Mixers		
Quantity	3	
Type	23 inch submersible propeller	
Manufacturer/Model	Flygt / 4650-Prop Code 125806J	
Capacity, each, gpm	9,840	
Clarifier		
Quantity	1	
Inside diameter, ft	85	
SWD, ft	12	
Design flow, mgd	2.25	
Peak flow, mgd	3.5	
Gravity Thickeners		
Quantity	1	
Inside diameter, ft	50	
SWD, ft	12	
Total SWD, ft	14	
Design flow, mgd	1.10	
Peak flow, mgd	2.20	
Thickened Residuals Pump Station		
No. pumps	2	
Type	Horizontal end suction centrifugal	
Manufacturer/Model	Fairbanks Morse / 2" x 2" Figure B5421	
Capacity, each, gpm	150	
Horsepower, each, hp	2	
Lagoon		
Quantity	1	
Length, each, ft	212 (at top of slope)	
Width, each, ft	97 (at top of slope)	
Side slope	2:1	
Max depth, ft	7	

Appendix B

Biosolids Processing Facilities and Equipment Evaluation

McAlpine Creek WWMF Biosolids Processing Facilities and Equipment

Primary Clarifier	North Plant			South Plant		
Quantity	2			4		
Diameter, ft	130			125		
SWD, ft	8			13		
Primary Sludge Pumps	North Plant			South Plant		
Quantity	2			4	6	
Type	Progressing cavity			Progressing cavity	Chopper pumps	
Manufacturer/Model	Moyno			Moyno	Vaughn	
Capacity, each, gpm	175			125	500	
Primary Sludge Gravity Thickeners	Original Gravity Thickeners			New Gravity Thickeners		
Quantity	2			2		
Diameter, ft	45			60		
SWD, ft	14			14		
Thickened Primary Sludge Pumps	Original Gravity Thickeners			New Gravity Thickeners		
Quantity	3			3		
Type	Progressing cavity			Progressing cavity		
Capacity, each, gpm	200			200		
Secondary Clarifiers	North Plant			South Plant		
Quantity	2	2	2	4	4	2
Diameter, ft	95	95	125	95	105	125
SWD, ft	10.5	13	14	11	8	13
WAS Pumps	North Plant			South Plant		
Quantity	1	2		2		
Type	Non-clog centrifugal	Non-clog centrifugal		Non-clog centrifugal		
Capacity, each, gpm	1,040	694		1,400		
Thickening Centrifuges						
Quantity	3					
Manufacturer/Model	Sharples / Alfa Laval - PM 95000					
Hydraulic loading rate, each, gpm	250-400					
TWAS Pumps						
Quantity	2					
Type	Progressing cavity					
Capacity, each, gpm	400					
Anaerobic Digesters						
Quantity	4			4		
Volume, MG	2.27			2.27		

Primary Clarifier	North Plant	South Plant
Diameter, ft	95	105
Cover type	Fixed	Fixed
Cover material	Concrete	Concrete
Digester Mixer		
Type	Lightning	
Manufacturer/Model	883Q100	
Quantity	8	
Dewatering Centrifuges		
Quantity	2	
Manufacturer/Model	Sharples / Alfa Laval - PM 95000	
Hydraulic loading rate, each, gpm	250-400	
Polymer System		
No. mix tanks and volume, each, gal	(3) 6,700 gal	
No. polymer tanks and volume, each, gal	(2) 9,000 gal	
Polymer feed pumps	(3) 0-35 gpm, Moyno	

Irwin Creek WWTP Biosolids Processing Facilities and Equipment

Primary Clarifier	
Quantity	3
Diameter, ft	125
SWD, ft	8.7
Primary Sludge Pumps	
Quantity	2
Type	Diaphragm
Manufacturer/Model	Dorr Oliver
Capacity, each, gpm	50
Secondary Clarifiers	
Quantity	3
Diameter, ft	125
SWD, ft	12
WAS Pumps	
Quantity	3
Type	Horizontal centrifugal
Manufacturer/Model	ITT Goulds
Capacity, each, gpm	300
Horsepower, hp	15
Gravity Belt Thickening	
Quantity	2
Manufacturer/Model	Ashbrook Simon-Hartley
Size, meters	1.5
Hydraulic loading rate, each, gpm	375
Horsepower, hp	10
TWAS Pumps	
Quantity	2
Type	Progressing Cavity
Manufacturer/Model	Netzsch NEMO
Capacity, each, gpm	75
Horsepower, hp	10
Anaerobic Digesters	
Quantity	6
Volume, MG	0.62
Diameter	65
Total height, ft	24 (tank operating level)
Cover type	Digesters 1-4: fixed Digesters 5-6: floating
Cover material	Digesters 1-4: Concrete Digesters 5-6: Metal
Digester Mixer	
Manufacturer/Model	Lightening 880Q20
Quantity	4
Horsepower, hp	0.75
Digester Sludge Recirculation Pumps	
Quantity	4
Type	Horizontal centrifugal

Primary Clarifier	
Manufacturer/Model	Wemco D4KHSDOSM
Capacity, each, gpm	300
Horsepower, hp	10
Digester Heat Exchanger	
Quantity	4
Type	Spiral
Manufacturer/Model	Alfa Laval Thermal Mod 23185
Digested Sludge Transfer Pumps	
Quantity	2
Type	Progressing cavity
Manufacturer/Model	Moyno
Capacity, each, gpm	100 - 200
Horsepower, hp	25
Digested Sludge Storage Tank	
Quantity	1
Volume, MG	2
Mixer Quantity	3
Mixer horsepower, hp	25
Dewatering BFPs	
Quantity	(2) – 2-meter (One unit installed; second unit to be added in Phase II Improvements Project)
Solids loading rate, each, lb/hr	1,100 – 1,400
Dewatering Feed Pumps	
Quantity	2
Type	Progressing cavity
Capacity, each, gpm	250
Polymer System (Thickening)	
Polymer blend system, capacity	Excel Polymer Feeder System Polymer Metering Pump: 0.75-15 gph Dilution Water: 180-1800 gph
No. mix tanks and volume, each, gal	(2), 3,390
No. polymer feed pumps and capacity, each, gph	(2), 558
Manufacturer	Pulsa Feeder
Polymer System (Dewatering)	
Liquid polymer preparation system	1,200 gal/hr dilute polymer solution 10 gph polymer feed pump 25 gpm polymer mixing pump
Polymer storage	10,500 gal bulk polymer FRP tank
Effluent Filters	
Quantity	10
Manufacturer	FB Leopold Bottoms
Area, each, sq.ft.	256
Filter Backwash Return Pumps	
Quantity	2
Type	Submersible centrifugal
Manufacturer/Model	Hydromatic Corp
Capacity, each, gpm	200
Horsepower, hp	7.5

Sugar Creek WWTP Biosolids Processing Facilities and Equipment

Primary Clarifier		
Quantity	4	
Diameter, ft	110	
SWD, ft	9	
Primary Sludge Pumps		
Quantity	4	
Type	Progressing cavity	
Manufacturer/Model	Moyno Model 2000 G1	
Capacity, each, gpm	100	
Horsepower, hp	15	
Secondary Clarifiers		
Quantity	4	2
Diameter, ft	85	140
SWD, ft	8	15.3
WAS Pumps		
Quantity	2	
Type	Progressing cavity	
Manufacturer/Model	Moyno Model 2000 G1	
Capacity, each, gpm	460	
Horsepower, hp	60	
Effluent Filters		
Quantity	10	
Manufacturer	FB Leopold Bottoms	
Area, each, sq.ft.	363	

Mallard Creek WRF Biosolids Processing Facilities and Equipment

Primary Clarifier			
Unit ID	1 &2 (Not Used)	3 &4	5
Quantity	2	2	1
Diameter, ft	55	60	85
SWD, ft	7.5	10.5	12
Primary Sludge Pumps			
Quantity	8		
Type	Air-operated diaphragm		
Manufacturer/Model	Dorr-Oliver (5); Gorman-Rupp (3)		
Capacity, each, gpm	170		
Secondary Clarifiers			
Unit ID	1&2	3	
Quantity	2	1	
Diameter, ft	100	100	
SWD, ft	15	15	
WAS Pumps			
Quantity	4		
Type	Progressing cavity		
Manufacturer/Model	Moyno		
Capacity, each, gpm	100		
Horsepower, hp	Pumps 1 ,2: 15hp Pumps 3 , 4: 10hp		
Thickening Centrifuges			
Quantity	2		
Manufacturer/Model	Humboldt		
Hydraulic loading rate, each, gpm	Centrifuge 3: 150 gpm Centrifuge 4: 210 gpm		
Horsepower, hp	Centrifuge 3: 100 hp Centrifuge 4 200 hp		
TWAS Pumps			
Quantity	2		
Type	Diaphragm		
Manufacturer/Model	Door-Oliver		
Capacity, each, gpm	170		
Anaerobic Digesters			
Unit ID	2, 3, 4	5	1
Quantity	3	1	1
Type (Primary, Secondary for Gas Storage)	Primary	Primary	Secondary
Volume, MG	0.48	1.00	0.48
Unit ID	2, 3, 4	5	1
Diameter	55	85	55
Total height, ft	29.5	31	29.5
Cover type	fixed	fixed	floating
Cover material	concrete	concrete	steel
Digester Mixer			
Type	Draft Tube Mixers		

Primary Clarifier	
Manufacturer/Model	Westech / Eimco
Quantity and horsepower, hp	(6) 24",5 hp (6) 24", 7.5 hp (4) 36" , 15 hp
Digester Sludge Recirculation Pumps	
Quantity	7
Type	Centrifugal
Manufacturer/Model	Wemco
Capacity, each, gpm	225
Horsepower, hp	25
Digester Heat Exchanger	
Quantity	4
Type	Combination Heater and Heat Exchanger
Manufacturer/Model	US Filter / Envirex
Digested Sludge Transfer Pumps	
Quantity	3
Type	progressing cavity
Manufacturer/Model	Moyno
Horsepower, hp	Pumps 1,2: 15 hp Pump 3: 25 hp
Dewatering Centrifuges	
Quantity	2
Manufacturer/Model	Humboldt
Hydraulic loading rate, each, gpm	Centrifuge 1: 80 gpm Centrifuge 2: 200 gpm
Horsepower, hp	Centrifuge 1: 100 hp Centrifuge 2: 200 hp
Effluent Filters	
Quantity	4
Manufacturer	Ondeo-Degremont
Type of filter	Traveling bridge
Area, each, sq.ft.	1,120
Filter Backwash Return Pumps	
Quantity	4
Type	Centrifugal
Manufacturer/Model	Flygt
Capacity, each, gpm	400
Horsepower, hp	3

McDowell Creek WRF Biosolids Processing Facilities and Equipment

Primary Clarifier		
Unit ID	1&2	3,4,5
Quantity	2	3
Diameter, ft	55	70
SWD, ft	7.5	12.25
Primary Sludge Pumps		
Quantity	9	
Type	Diaphragm	
Manufacturer/Model	Dorr Oliver	
Capacity, each, gpm	6	
Horsepower, hp	air	
Secondary Clarifiers		
Quantity	4	
Diameter, ft	100	
SWD, ft	15	
WAS Pumps		
Quantity	3	2
Type	progressing cavity	centrifugal
Manufacturer/Model	Netzsch	Fairbanks
Capacity, each, gpm	75	110
Horsepower, hp	15	
Gravity Belt Thickening		
Quantity	2	
Manufacturer/Model	Ashbrook Simon-Hartley	
Size, meters	1.5	
Hydraulic loading rate, each, gpm/meter	50-80	
TWAS Pumps		
Quantity	2	
Type	progressing cavity	
Manufacturer/Model	Netzsch	
Capacity, each, gpm	76 gpm at 300 rpm	
Horsepower, hp	15	
Anaerobic Digesters		
Unit ID	1,2,3,4	5
Quantity	4	1
Type (Primary, Secondary for Gas Storage)	Digesters 1,2,4: Primary; Digester 3: Secondary	Digesters 5: Primary
Volume, MG	0.48	1.43
Diameter, ft	55	90
SWD, ft	27	30
Cover type	floating	fixed dome
Cover material	steel	concrete
Digester Mixer		
Type	Draft tube mixers	
Manufacturer/Model	Eimco	
Quantity	7	

Primary Clarifier		
Horsepower, hp	2.5 to 11.3	
Digester Sludge Recirculation Pumps		
No. pumps	6	
Type	horizontal chopper	
Manufacturer/Model	Vaughan	
Capacity, each, gpm	Pumps 1-4: 250 gpm Pumps 5-6: 500 gpm	
Horsepower, hp	Pumps 1-4: 10 hp Pumps 5-6: 20 hp	
Digester Heat Exchanger		
Quantity	6	
Type	Spiral	
Manufacturer/Model	Alfa Laval	
Capacity (hot/cold), each, gpm	300/350	
Digested Sludge Transfer Pumps		
Quantity	4	
Type	progressing cavity	
Manufacturer/Model	2 Moyno 2 Netzsch	
Capacity, each, gpm	300	
Horsepower, hp	30	
Dewatering Belt Filter Press		
Quantity	2	
Manufacturer/Model	2-Meter Ashbrook Klampress	
Hydraulic loading rate, each, gpm	120-180	
Polymer System		
Polymer blend system, capacity	in line blending	
No. polymer tanks, volume, each, gal	(1) 4,500	
No. polymer transfer pumps, capacity, each, gph	(4), 0.39-3.90	
No. polymer feed pumps, capacity, each, gpm	(4), 0.32-3.20	
Filter Backwash Return Pumps		
Quantity	2	2
Type	centrifugal	centrifugal
Manufacturer/Model	Fairbanks Morse	Ebara
Capacity, each, gpm	3,000	3,010
Horsepower, hp	30	40

Appendix C

Reusers Survey

Questionnaire

Identification of Potential Biosolids Product Reusers

Date: ____________________

1. User Category: ____________________
2. Name of Business: ____________________
    a. Address: ____________________
    b. Telephone: ____________________
    c. Contact: ____________________
3. Do you currently sell/use a biosolids-derived fertilizer or soil amendment? ______
    a. What type do you sell/use? ____________________
    b. How much do you sell/use? ____________________
    c. How is the product used? ____________________
    d. What is the cost of the product you currently use/sell? ____________
4. What is the typical seasonality of product use/sale? ____________
5. What are your NPK (Nitrogen-Phosphorus-Potassium) requirements?

    ____

6. Would you be interested in selling/using a biosolid-derived product?

    ____

7. What product qualities are most important to you/your customers (equipment limitations, spreadability, odor, and price)?

8. Any additional comments?

Appendix D

WWTP Pre-Treatment Alternatives Evaluation Total Life Cycle Cost

The following tables provide an opinion of probable construction and O&M cost for the WWTP Pre-Treatment Alternatives. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period.

Alternative 3-4: McAlpine Creek WWMF THP

McAlpine Creek WWMF Total Life Cycle Cost

Table 1 Summary of Capital and O&M Costs for McAlpine Creek WWMF

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
Sugar Creek WWTP WAS EQ Tank (Concrete Tank with TOW at Grade Elevation)	$0.24	$0.31	$0.55
Yard Piping - Gravity Thickeners to New Blend Tank	$0.00	$0.15	$0.15
Yard Piping - WAS PS to New Blend Tank	$0.00	$0.05	$0.05
Yard Piping - From Thermal Hydrolysis Process to New Digesters	$0.00	$0.03	$0.03
Outdoor Solids Blending Tank and Screens	$2.27	$1.82	$4.08
Pre-Dewatering and Cake Bins	$2.96	$5.28	$8.24
Thermal Hydrolysis	$10.60	$2.14	$12.74
Anaerobic Digester	$3.28	$3.03	$6.31
Existing Thickening/Dewatering Complex Upgrade	$0.93	$0.93	$1.86
Phosphorus Removal	$3.10	$1.25	$4.35
Residuals Management Facility Expansion	$0.30	$2.45	$2.75
Subtotal Direct Construction Costs	$23.68	$17.45	$41.12
Subtotal Indirect Construction Costs			$28.6
Total Capital Cost			$69.72
O&M Cost			**20-Year NPV ($M)**
Pre-Dewatering			$48.05
Pre-Treatment			$15.55
An Dig			$4.63
Dewatering			$13.02
Land Application			$31.75
Total Net Present O&M Cost			**$112.99**
Total Present Worth Cost			**Total ($ M)**
Capital Cost + O&M Cost			**$182.71**

Alternative 3-6: McAlpine Creek WWMF Thermal Hydrolysis & Irwin Creek WWMF Pumping

McAlpine Creek WWMF Total Life Cycle Cost

Table 2 Summary of Capital and O&M Costs for McAlpine Creek WWMF

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
Sugar & Irwin Creek WWMF WAS Equalization Tanks	$0.24	$0.31	$0.55
Yard Piping - Gravity Thickeners to New Blend Tank	$0.00	$0.15	$0.15
Yard Piping - WAS PS to New Blend Tank	$0.00	$0.05	$0.05
Yard Piping - From THP to Digesters	$0.00	$0.03	$0.03
Yard Piping - From Irwin Creek WWMF to McAlpine Creek WWMF	$0.00	$7.88	$7.88
Solids Blending Tank and Screens	$2.27	$1.82	$4.08
Pre-Dewatering and Cake Bins	$3.70	$5.47	$9.17
Thermal Hydrolysis Process	$10.60	$2.14	$12.74
Anaerobic Digester Improvements	$3.28	$3.03	$6.31
Thickening/Dewatering Complex Upgrade	$0.93	$0.93	$1.86
Phosphorus Removal	$3.10	$1.25	$4.35
Residuals Management Facility Expansion	$0.30	$3.51	$3.81
Subtotal Direct Construction Costs	**$24.42**	**$26.58**	**$50.99**
Subtotal Indirect Construction Costs			**$36.06**
Total Capital Cost			**$87.05**
O&M Cost			**20-Year NPV ($M)**
Pre-Dewatering			$57.51
Pre-Treatment			$18.02
An Dig			$4.56
Dewatering			$15.66
Land Application			$38.19
Total Net Present O&M Cost			**$133.94**
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			**$220.99**

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Irwin Creek WWMF Total Life Cycle Cost

Table 3 Summary of Capital and O&M Costs for Irwin Creek WWMF

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
Irwin Creek WWMF Solids Transfer Pump Stations	$0.16	$0.28	$0.44
Subtotal Direct Construction Costs	**$0.16**	**$0.28**	**$0.44**
Subtotal Indirect Construction Costs			**$0.36**
Total Capital Cost			**$0.80**
O&M Cost			**20-Year NPV ($M)**
Pumping Operations			$0.30
Total Net Present O&M Cost			**$0.30**
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			**$1.10**

Alternative 3-7: Electrical Lysis at All WWTPs

McAlpine Creek WWMF Total Life Cycle Cost

Table 4 Summary of Capital and O&M Costs for McAlpine Creek WWMF

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
New Electrical Lysis Building	$6.90	$2.37	$9.27
Existing Thickening/Dewatering Complex Upgrade	$1.71	$1.15	$2.86
Sugar & Irwin Creek WWMF WAS Equalization Tanks	$0.24	$0.31	$0.55
Phosphorus Removal	$2.20	$1.06	$3.26
Residuals Management Facility Expansion	$0.30	$7.20	$7.50
Subtotal Direct Construction Costs	**$11.35**	**$12.09**	**$23.44**
Subtotal Indirect Construction Costs			$16.78
Total Capital Cost			$40.02
O&M Cost			**20-Year NPV ($M)**
WAS Thickening			$22.62
Electrical Lysis			$0.20
An Dig			$7.22
Dewatering			$18.52
Land Application			$35.79
Total Net Present O&M Cost			**$84.34**
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			**$124.36**

Irwin Creek WWMF Total Life Cycle Cost

Table 5 Summary of Capital and O&M Costs for Irwin Creek WWMF

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
New Dewatering Facility	$1.18	$2.53	$3.71
New Anaerobic Digester	$1.28	$2.28	$3.56
New Electrical Lysis Building	$1.50	$0.80	$2.30
Subtotal Direct Construction Costs	**$3.96**	**$5.61**	**$9.57**
Subtotal Indirect Construction Costs			**$7.80**
Total Capital Cost			**$17.37**
O&M Cost			**20-Year NPV ($M)**
WAS Thickening			$3.56
Electrical Lysis			$2.80
An Dig			$4.10
Dewatering			$5.05
Land Application			$14.09
Total Net Present O&M Cost			**$29.59**
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			**$46.96**

Mallard Creek WRF Total Life Cycle Cost

Table 6 Summary of Capital and O&M Costs for Mallard Creek WRF

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
Biogas Conditioning System	$0.41	$0.32	$0.73
Thickening/Dewatering Improvements	$1.47	$0.60	$2.07
New Electrical Lysis Building	$1.50	$0.80	$2.30
Subtotal Direct Construction Costs	**$3.38**	**$1.72**	**$5.10**
Subtotal Indirect Construction Costs			**$4.27**
Total Capital Cost			**$9.37**
O&M Cost			**20-Year NPV ($M)**
WAS Thickening			$7.09
Electrical Lysis			$1.34
An Dig			$1.14
Dewatering			$5.95
Land Application			$4.77
Total Net Present O&M Cost			**$20.29**
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			**$29.66**

McDowell Creek WRF Total Life Cycle Cost

Table 7 Summary of Capital and O&M Costs for McDowell Creek WRF

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
New Dewatering Facility	$0.00	$3.67	$3.67
New Electrical Lysis Building	$1.50	$0.80	$2.30
Subtotal Direct Construction Costs	$1.50	$4.47	$5.97
Subtotal Indirect Construction Costs			$4.21
Total Capital Cost			$10.18
O&M Cost			**20-Year NPV ($M)**
WAS Thickening			$2.54
Electrical Lysis			$1.38
An Dig			$0.53
Dewatering			$2.17
Land Application			$4.56
Total Net Present O&M Cost			**$11.18**
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			**$21.36**

Appendix E

WWTP Drying Alternatives Evaluation Total Life Cycle Cost

The following tables provide an opinion of probable construction and O&M cost for the WWTP Drying Alternatives. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period.

Alternative 4-4: McAlpine Thermal Drying

McAlpine Total Life Cycle Cost

Table 1 Summary of Capital and O&M Costs for McAlpine

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
Sugar & Irwin WAS EQ Tanks	$0.24	$0.31	$0.55
Existing Thickening/Dewatering Complex Upgrade	$1.71	$1.15	$2.86
Residuals Management Facility Expansion	$0.30	$7.86	$8.16
Thermal Dryer	$17.60	$9.71	$27.31
Phosphorus Removal System	$2.20	$1.06	$3.26
Subtotal Direct Construction Costs	$22.05	$20.10	$42.15
Subtotal Indirect Construction Costs			$30.30
Total Capital Cost			$72.45
O&M Cost			**20-Year NPV ($M)**
WAS Thickening			$22.62
An Dig			$7.22
Dewatering			$19.66
Drying			$65.40
Total Net Present O&M Cost			$114.89
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			$187.34

Alternative 4-12: McAlpine Thermal Drying + McDowell Solar Drying

McDowell Total Life Cycle Cost

Table 2 Summary of Capital and O&M Costs for McDowell

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
New Dewatering Facility	$0.00	$0.45	$0.45
Solar Dryer	$5.53	$4.10	$9.63
Subtotal Direct Construction Costs	$5.53	$4.55	$10.08
Subtotal Indirect Construction Costs			$7.20
Total Capital Cost			$17.28
O&M Cost			**20-Year NPV ($M)**
WAS Thickening			$2.54
An Dig			$2.97
Dewatering			$2.14
Land Application			$3.62
Total Net Present O&M Cost			$11.27
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			**$28.55**

Appendix F

WWTP Pre-Treatment & Drying Alternatives Evaluation Total Life Cycle Cost

The following tables provide an opinion of probable construction and O&M cost for the WWTP Pre-Treatment & Drying Alternatives. The life cycle cost represents the sum of capital and O&M costs incurred over the 2016 to 2035 period.

Alternative 3+4-1: McAlpine Thermal Hydrolysis & Drying

McAlpine Total Life Cycle Cost

Table 1 Summary of Capital and O&M Costs for McAlpine

Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
Sugar Creek WWTP WAS EQ Tank (Concrete Tank with TOW at Grade Elevation)	$0.24	$0.31	$0.55
Yard Piping - Gravity Thickeners to New Blend Tank	$0.00	$0.15	$0.15
Yard Piping - WAS PS to New Blend Tank	$0.00	$0.05	$0.05
Yard Piping - From Thermal Hydrolysis Process to New Digesters	$0.00	$0.03	$0.03
Outdoor Solids Blending Tank and Screens	$2.27	$1.82	$4.08
Pre-Dewatering and Cake Bins	$2.96	$5.28	$8.24
Thermal Hydrolysis	$10.60	$2.14	$12.74
Anaerobic Digester	$3.28	$3.03	$6.31
Existing Thickening/Dewatering Complex Upgrade	$0.93	$0.93	$1.86
Phosphorus Removal	$3.10	$1.25	$4.35
Thermal Drying	$8.20	$4.93	$13.13
Subtotal Direct Construction Costs	$31.58	$19.93	$51.50
Subtotal Indirect Construction Costs			$37.10
Total Capital Cost			$88.60
O&M Cost			**20-Year NPV ($M)**
Pre-Dewatering			$48.05
Pre-Treatment			$15.55
An Dig			$4.63
Dewatering			$13.02
Thermal Drying			$33.16
Total Net Present O&M Cost			$114.40
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			$203.00

Alternative 3+4-2: McAlpine Thermal Hydrolysis & Drying with Irwin Pumping

McAlpine Total Life Cycle Cost

Table 2 Summary of Capital and O&M Costs for McAlpine

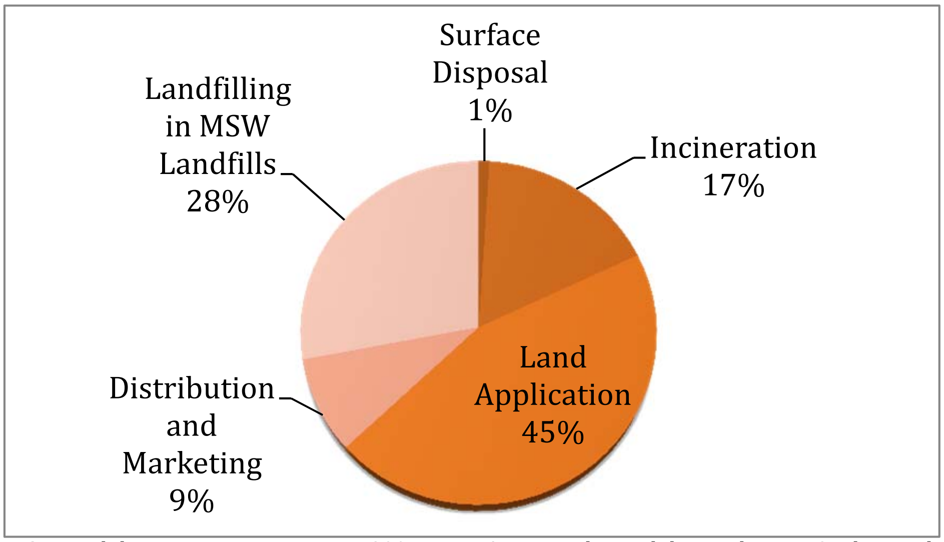
Capital Cost	Equipment ($M)	Labor & Material ($M)	Total ($M)
Sugar Creek WWTP WAS EQ Tank	$0.24	$0.31	$0.55
Yard Piping - Gravity Thickeners to New Blend Tank	$0.00	$0.15	$0.15
Yard Piping - WAS PS to New Blend Tank	$0.00	$0.05	$0.05
Yard Piping - From Thermal Hydrolysis Process to New Digesters	$0.00	$0.03	$0.03
Yard Piping - From Irwin to McAlpine	$0.00	$7.88	$7.88
Outdoor Solids Blending Tank and Screens	$2.27	$1.82	$4.08
Pre-Dewatering and Cake Bins	$3.70	$5.47	$9.17
Thermal Hydrolysis	$10.60	$2.14	$12.74
Anaerobic Digester	$3.28	$3.03	$6.31
Existing Thickening/Dewatering Complex Upgrade	$0.93	$0.93	$1.86
Phosphorus Removal	$3.10	$1.25	$4.35
Thermal Drying	$8.80	$5.27	$14.07
Subtotal Direct Construction Costs	$32.92	$28.34	$61.25
Subtotal Indirect Construction Costs			$44.63
Total Capital Cost			$105.88
O&M Cost			**20-Year NPV ($M)**
Pre-Dewatering			$57.51
Pre-Treatment			$18.02
An Dig			$4.56
Dewatering			$15.66
Thermal Drying			$37.05
Total Net Present O&M Cost[2]			$132.80
Total Life Cycle Cost			**Total ($M)**
Capital Cost + O&M Cost			$238.68

Appendix G

National and Regional Trends in Biosolids Management

National Trends

- Approximately 8 million dry tons of solids are generated annually nationwide



U.S. Biosolids Management Practices. 2007. NEBRA. National Biosolids Regulations, Quality, End Use & Disposal Survey

End-use Opportunities

Agricultural Land Application

- Fertilizer/Soil Conditioner

Energy Recovery

- Excess Heat Recovery
- Methane Recovery
- Biogas Recovery
- Incineration, Gasification
- Brick & Cement Kilns
- Furnaces

Non-Agricultural Land Application

- Forestry
- Parks & Recreation
- Land Reclamation
- Horticulture, Landscaping
- Domestic Use
- Landfill Cover

Examples of Large WWTP Biosolids Management Strategies

Metropolitan Water Reclamation District of Greater Chicago (MWRDGC)

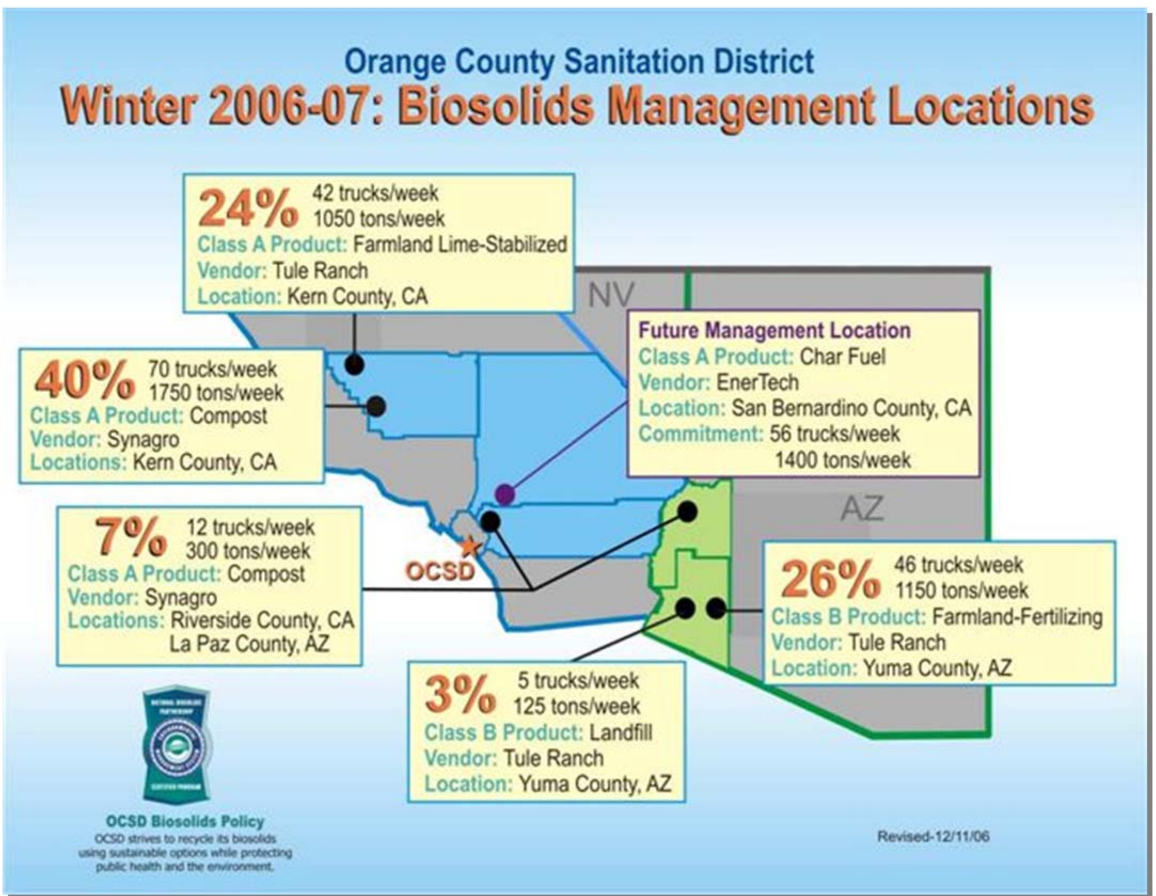
- Wastewater Treatment Facilities: 7
- Annual Biosolids Quantity: 190,000 DT
- Method of Biosolids Management:
  - Anaerobic digestion, centrifuge dewatering, lagoon aging, air drying and thermal drying
  - Direct land application or landfilling of Class B biosolids
  - Stickney WRP thermal dryer produces Class A biosolids for D&M

City of Los Angeles, California

- Wastewater Treatment Facilities: 4
- Annual Biosolids Quantity: 100,000 DT
- Method of Biosolids Management:
  - WTP residuals discharged to sewer system
  - Thickened sludge thermophicially digested in egg-shaped digesters to produce a Class A product
  - Biosolids are centrifuge dewatered
  - In 2005 approximately 99 percent of biosolids was land applied to agricultural land in Kern, Co, CA and Western Arizona. The remaining was composted within the City

Orange County Sanitation District, California (OCSD)

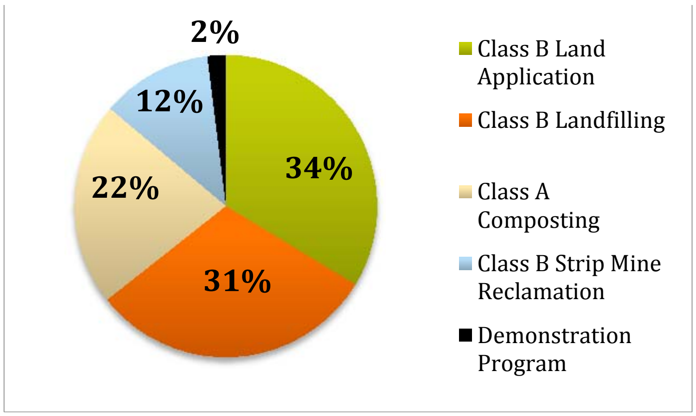
- Wastewater Treatment Facilities: 2
- Annual Biosolids Quantity : 55,000 DT
- Method of Biosolids Management:
  - Solids are anaerobically digested, thickened and dewatered to produce Class B cake
  - Final product is either land applied, landfilled or composted



Philadelphia Water Department (PWD)

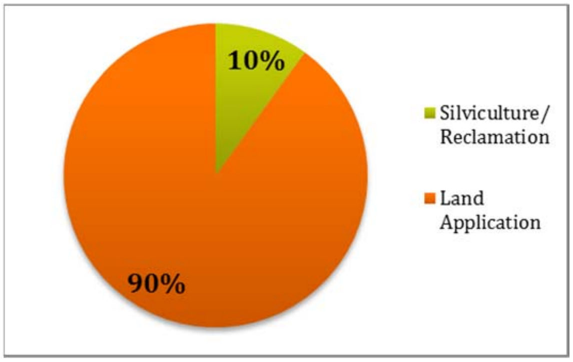
- Wastewater Treatment Facilities: 3
- Annual Biosolids Quantity : 66,000 DT
- Method of Biosolids Management:
  - Sludges are thickened, anaerobically digested and transferred by pipeline/barge to central facility to be centrifuge dewatered and distributed
  - PWD plans to convert to 100 percent Class A

PWD Biosolids Recycling Facility



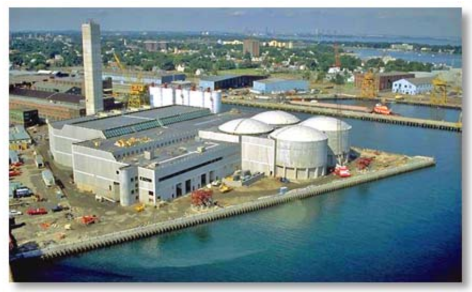
DC Water

- Wastewater Treatment Facilities: 1
- Annual Biosolids Quantity : 125,000 DT
- Method of Biosolids Management:
  - Primary and waste-activated sludges are thickened, dewatered and lime-stabilized to produce Class B product for land application
  - Currently constructing Cambi THP and anaerobic digesters to produce Class A product



Massachusetts Water Resources Authority (MWRA)

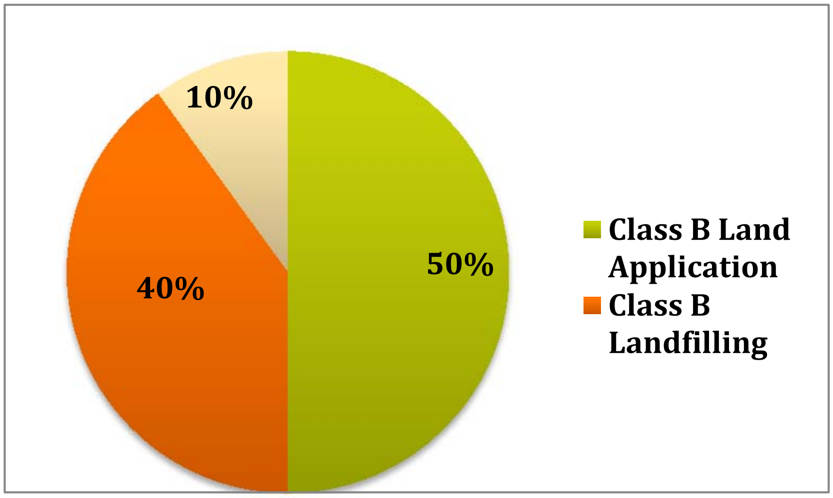
- Wastewater Treatment Facilities: 1
- Annual Biosolids Quantity : 33,000 DT
- Method of Biosolids Management:
  - Primary and Waste activated sludges are thickened, anaerobically digested and transferred by pipeline for centrifuge dewatering and thermal drying
  - Final product is Class A



Miami – Dade Water and Sewer Department (MDWASD)

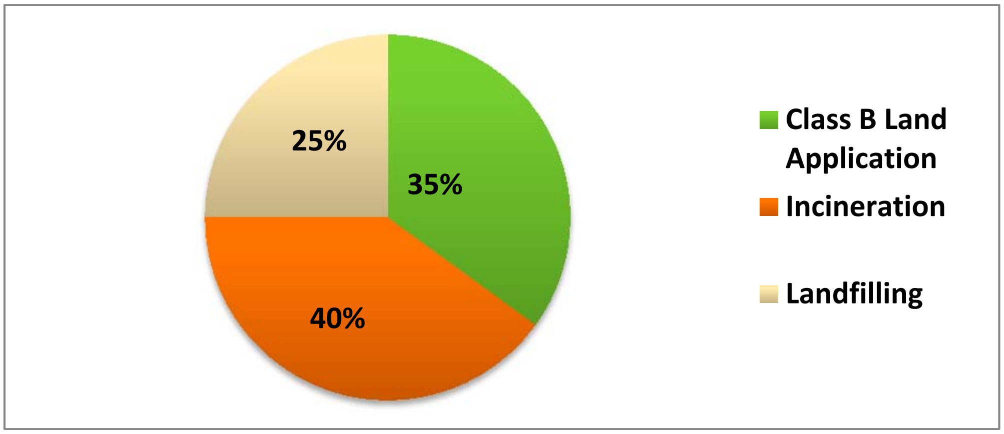
- Wastewater Treatment Facilities: 3
- Annual Biosolids Quantity : 32,000 DT
- Method of Biosolids Management:
  - Centralization of North and Central
  - Central District – WAS is thickened, digested and dewatered to produce Class B biosolids for land application and landfilling

- Southern District – WAS is thickened, digested, dewatered, and air-dried on site. The “dry season” produces Class A, composted biosolids that are sold to soil blenders. The “wet season” produces Class B material that is either land applied or disposed of in a landfill.



Allegheny County Sanitation Authority, Pennsylvania (ALCOSAN)

- Wastewater Treatment Facilities: 1
- Annual Biosolids Quantity : 40,000 DT
- Method of Biosolids Management:
  - Primary and waste activated sludges are thickened and dewatered
  - Biosolids are incinerated, landfilled or land applied
  - Class A technologies under investigation



Allegheny County Sanitation Authority, Pennsylvania

National Trends In Biosolids Management Strategies

Summary of Stabilization Practices

Client	Mesophilic Digestion	Thermophilic Digestion	Lime
MWRDGC	✓		
LA		✓	
OCSD	✓		✓
PWD	✓		
MDWASD	✓		
DC WATER	✓		✓
MWRA			
ALCOSAN	✓		✓

Summary of Biogas Utilization

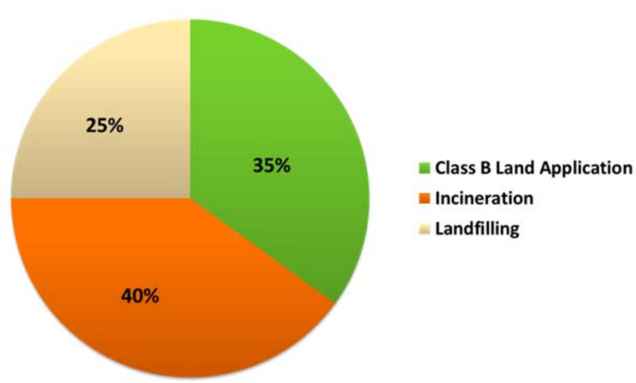
Client	Digester Heating	Space Heating	Power Production	Off-Site Use
MWRDGC	✓	✓	✓	
LA				✓
OCSD	✓	✓	✓	
PWD	✓	✓	✓	✓
MDWASD	✓	✓	✓	
DC WATER			✓	
MWRA	✓	✓	✓	
ALCOSAN				

Summary of Utilization Practices

Client	Land Application	Strip-Mine Reclamation	Thermal Drying	Composting	Landfilling	Incineration
MWRDGC	✓	✓	✓		✓	
LA	✓				✓	
OCSD	✓		✓	✓	✓	
PWD	✓	✓	✓	✓	✓	
MDWASD	✓			✓	✓	
DC WATER	✓					
MWRA			✓			
ALCOSAN	✓				✓	✓

Summary of National Trends

- Anaerobic digestion preferred stabilization technology.
- Energy recovery very important.
- Class A technologies interest increasing.
- Centrifuge dewatering use nearly universal.
- Beneficial use typical "policy".
- Landfilling usually among utilization practices.



Regional Trends in Biosolids Management

North Carolina

- Cary, NC
  - Since 2003, all sludge undergoes thermal drying to produce pellets. Currently sold to Soil Plus
- Winston Salem, NC
  - Thermally dried, Class A pellets sold to Soil Plus
- Raleigh, NC
  - Current: Alkaline-stabilized Class A, Class B biosolids, and contract composting
  - Master Planning: Install THP, construct anaerobic digesters, and build solar dryers. To produce a combination of Class A and Class B biosolids

South Carolina

- REWA
  - Anaerobic digestion and dewatering to produce Class B biosolids for land application
- Columbia
  - Currently landfilling. Future upgrades to Class B
- Charleston
  - Landfilling
  - Waste-to-Energy: Gas collection off anaerobic digesters
- Spartanburg
  - Currently landfilling
  - Master Planning: build anaerobic digesters and solar dryers to produce Class A biosolids

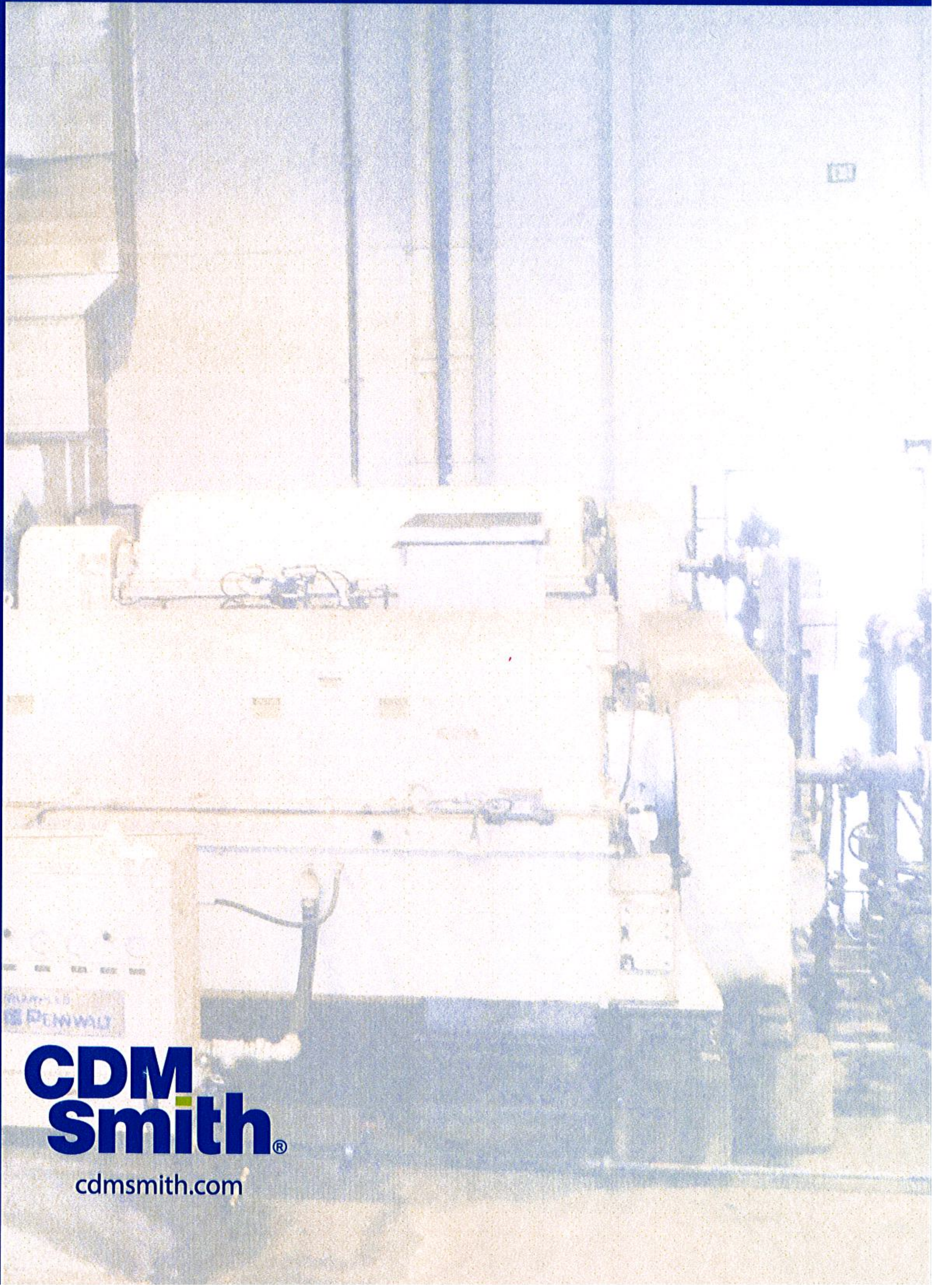
Georgia

- Gwinnett County, GA
  - F. Wayne Hill
    - 60 MGD
    - CHP
    - FOG receiving

        - Anaerobic digestion, dewatering, and landfill of Class B
    - Yellow River WRF
        - 22 MGD
        - Pump Sludge to F. Wayne Hill for further processing
    - Crooked Creek
        - Landfills Class B

Virginia

- Alexandria
    - Class A cake through an digestion, pasteurization and dewatering
    - Land applied
- Arlington
    - Dewatering, lime stabilization and land application of Class B
- Richmond
    - Land applies Class B
- Prince William County
    - Incineration



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