Metropolitan Water Reclamation District of Greater Chicago

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TO THE JUNE EDITION

OF THE 2019

M&R SEMINAR SERIES

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  - AUTOMATED EXTERNAL DEFIBRILLATOR (AED) LOCATED OUTSIDE
- PLEASE SILENCE CELL PHONES OR SMART PHONES
- QUESTION AND ANSWER SESSION WILL FOLLOW PRESENTATION
- PLEASE FILL EVALUATION FORM
- SEMINAR SLIDES WILL BE POSTED ON MWRD WEBSITE (www. MWRD.org: Home Page ⇒ Reports ⇒ M&R Data and Reports ⇒ M&R Seminar Series ⇒ 2019 Seminar Series)
- STREAM VIDEO WILL BE AVAILABLE ON MWRD WEBSITE (www.MWRD.org: Home Page ⇒ MWRDGC RSS Feeds)

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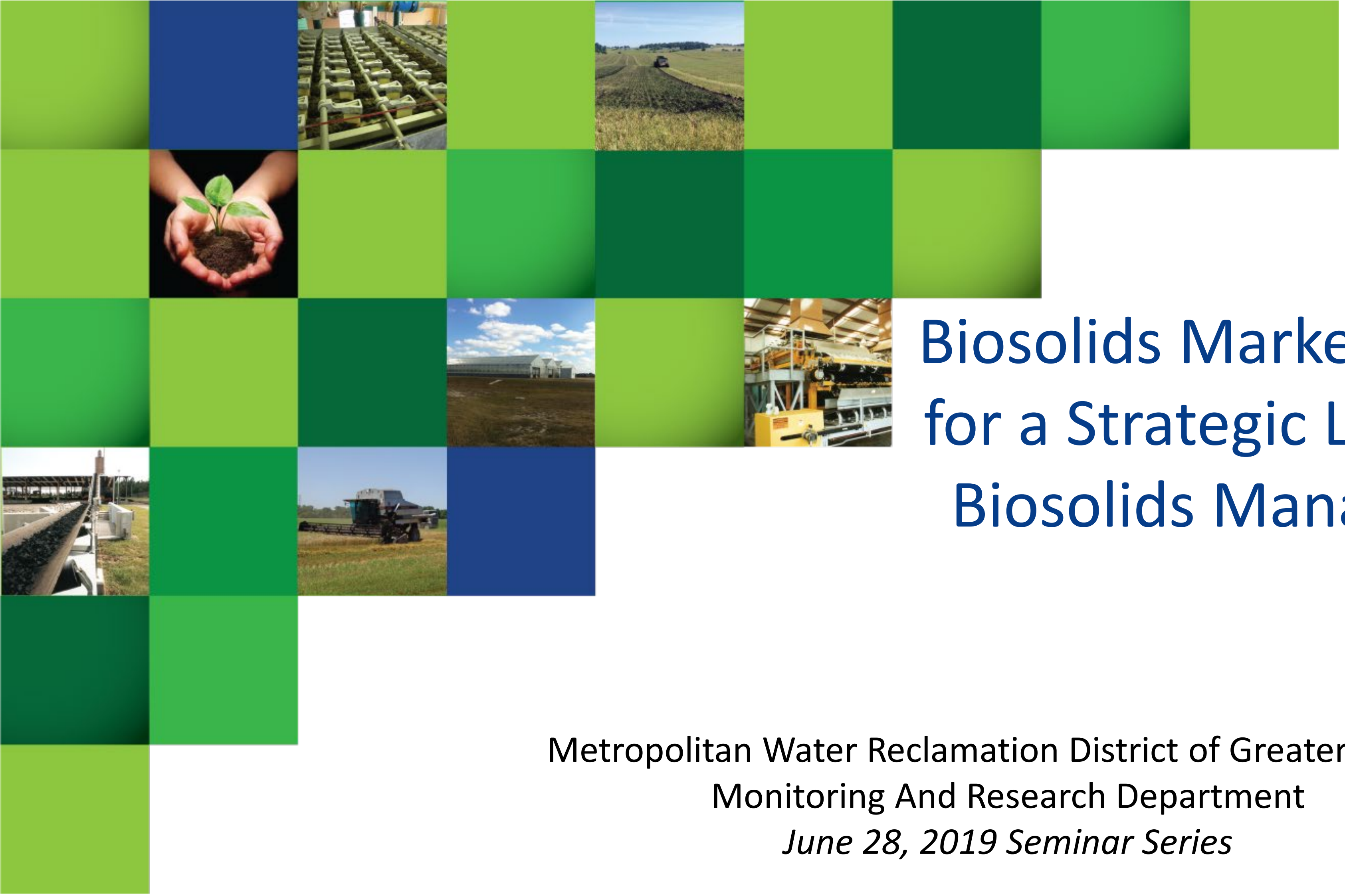
Dr. Irene Teshamulwa (Tesha) Okioga is a Senior Engineering Project Manager with Charlotte Water in Charlotte, North Carolina. She holds a **PhD** in Infrastructure and Environmental Systems from the University of North Carolina at Charlotte, a Master's degree in Civil and Environmental Engineering from the Massachusetts Institute of Technology, and a Bachelors degree in Civil Engineering from the University of Nairobi, Kenya.

Her specialties include demand forecasting, decision analysis, project prioritization, capital planning and project management; and water/wastewater design. She is currently managing projects and programs with an estimated capital cost of approximately $700 Million anticipated over the next 5 to 10-year period.

Dr. Okioga has more than 15 years of experience supporting and working with the World Agroforestry Center, the United Nations, Black & Veatch, and Charlotte Water. She is a licensed Professional Engineer, a Leadership in Energy and Environmental Design (LEED) Accredited Professional and Envision Sustainability Professional.



Biosolids Market Analysis for a Strategic Long-term Biosolids Management

Metropolitan Water Reclamation District of Greater Chicago
Monitoring And Research Department
June 28, 2019 Seminar Series

CHARLOTTE WATER

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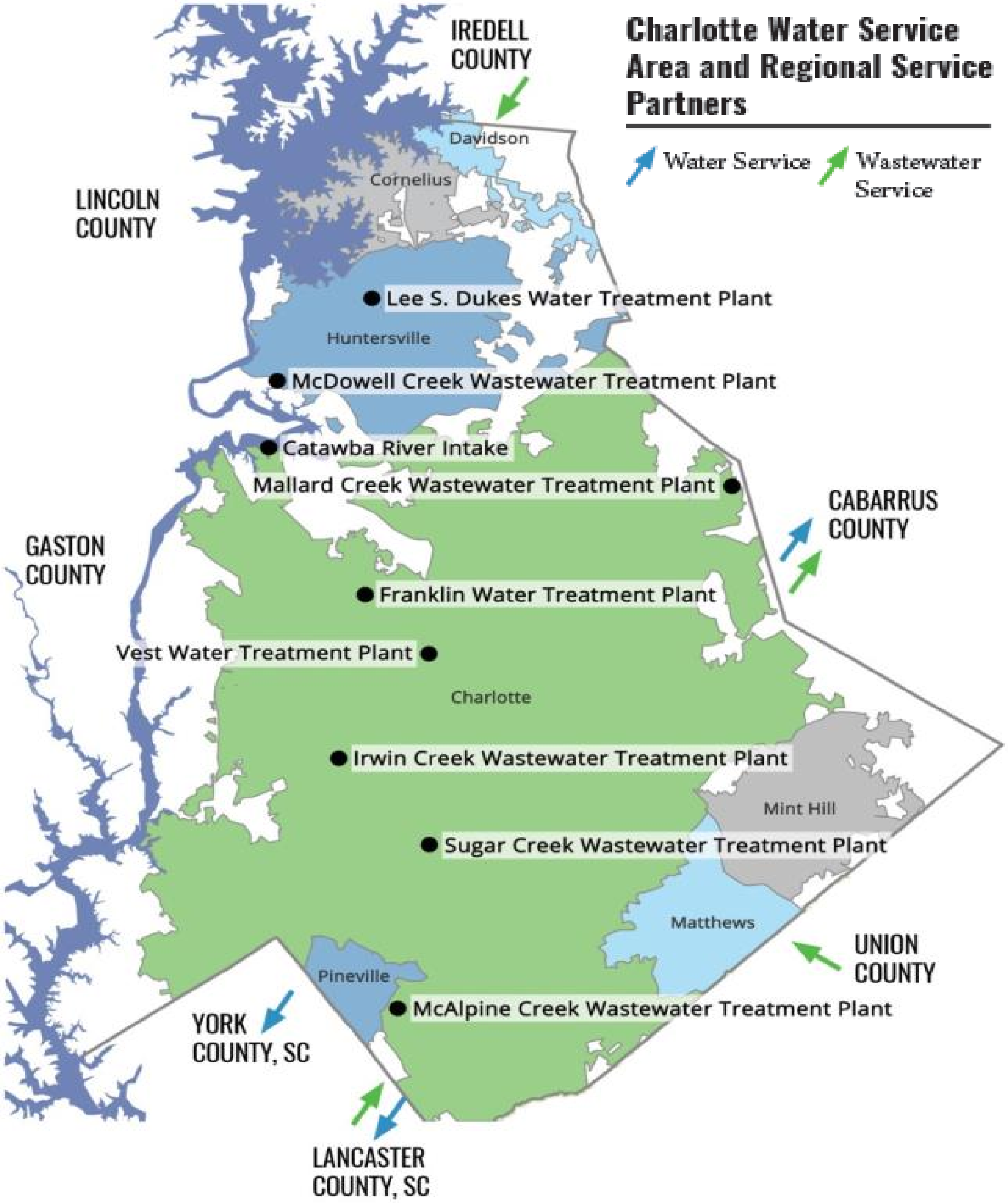
Agenda

- Introduction and Background – Charlotte Water
- Current Wastewater and Biosolids Management Operations and Challenges
- Visions and Goals of the Biosolids Master Plan and Related Projects
- Preliminary Implementation Schedule
- Questions and Discussion

Introduction and Background
Charlotte Water

Charlotte Water by the Numbers

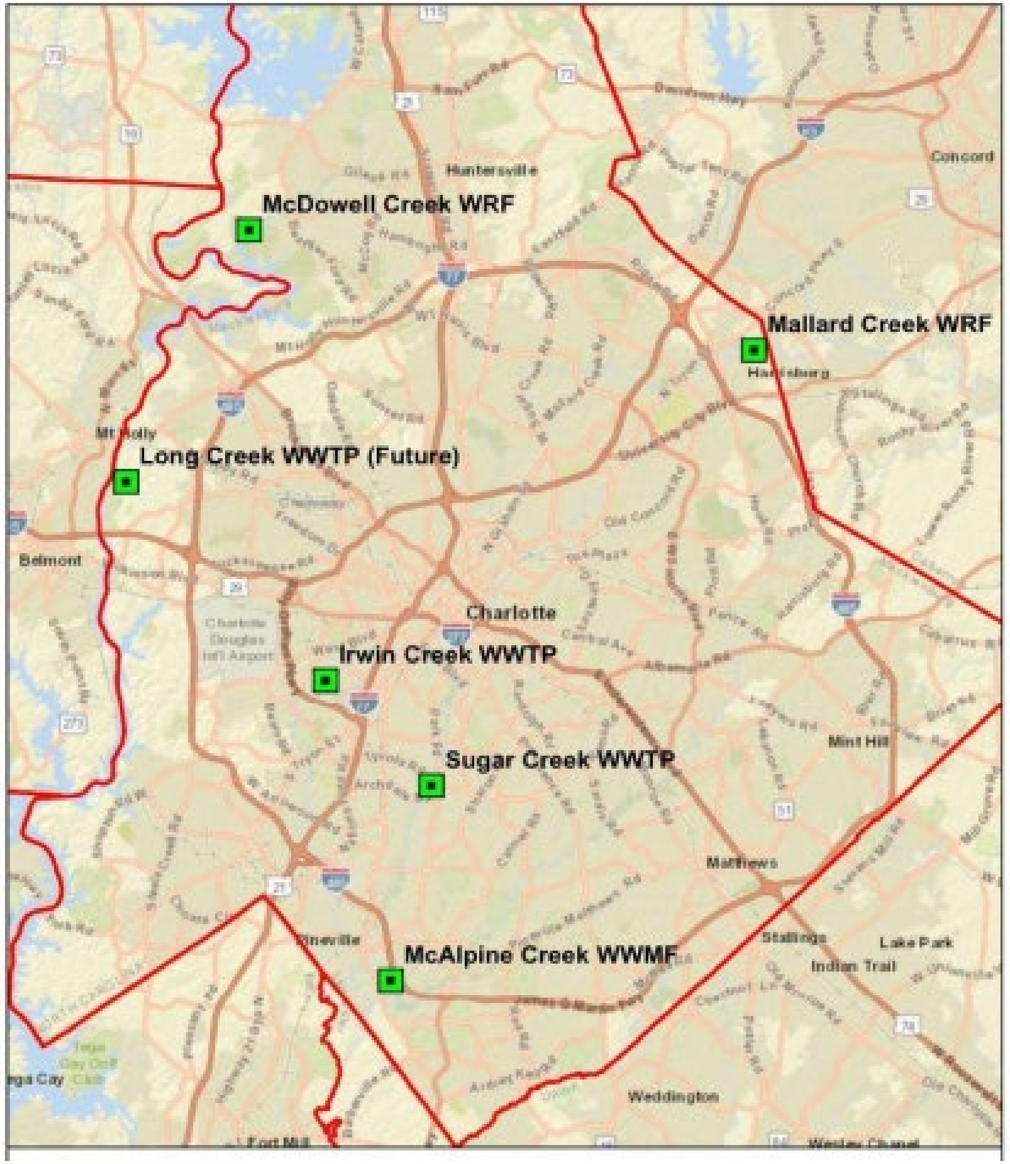
- **2** Drinking Water Supply Intakes
- **2** Raw Water Reservoirs
- **3** Drinking Water Treatment Plants
- **1M** People served in Mecklenburg County
- **8** Governments Served (Mecklenburg County, Town of Davidson, Town of Cornelius, Town of Huntersville, City of Charlotte, Town of Mint-Hill, Town of Matthews, Town of Pineville)
- **8K** Miles of Water and Wastewater Mains
- **7** Wastewater Treatment Plants (Owned & Operated)
- **17** Staffed Facilities
- **81** Wastewater Lift Stations
- **958** Full-time Positions



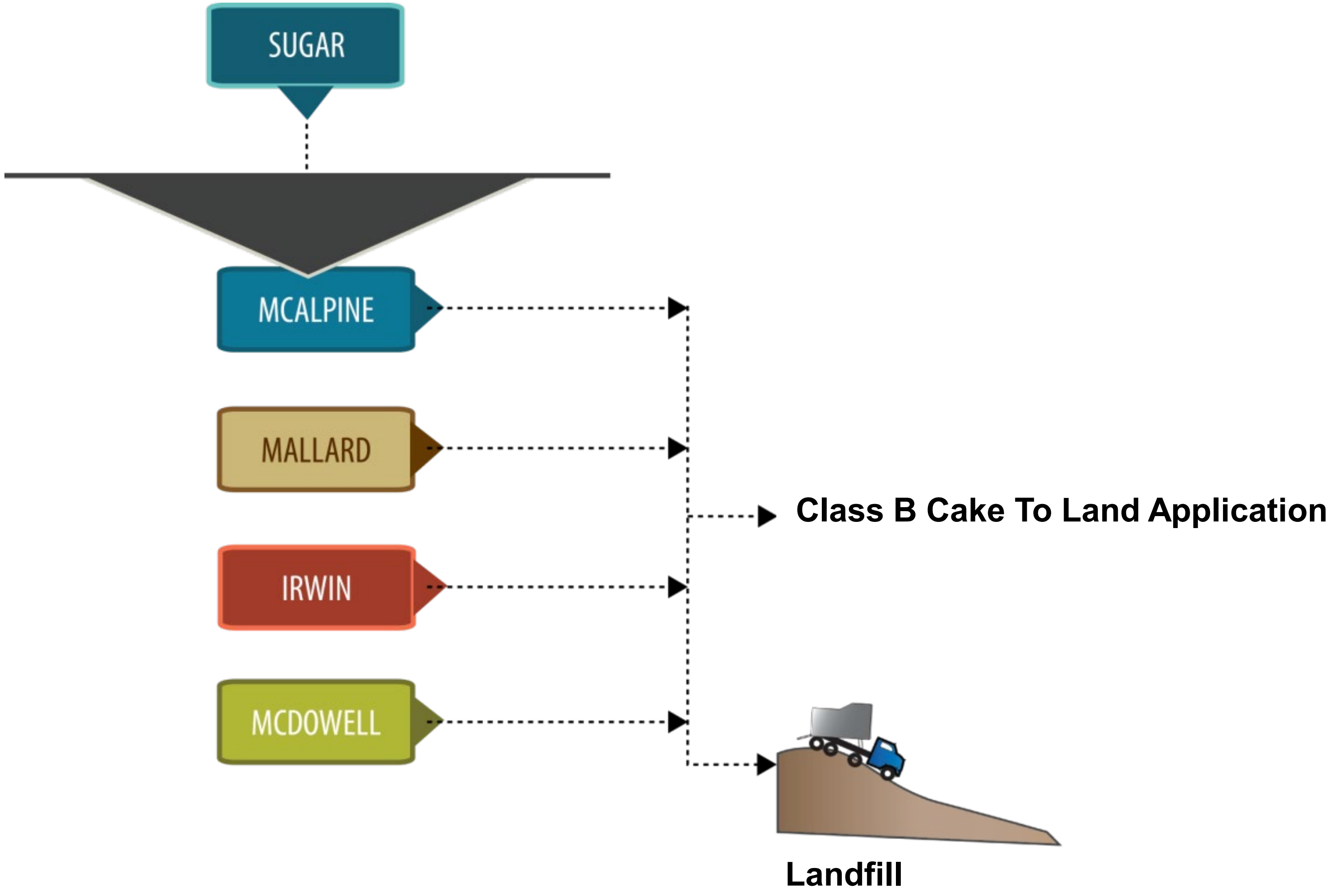
Current wastewater and biosolids management operations and challenges

Wastewater Operations

- CLT Water operates 5 major WWTPs ranging from 12 mgd to 64 mgd
- 4 plants have anaerobic digestion and dewatering
- Sugar Creek WWTP transfers solids to McAlpine WWMF for treatment
- Future plans to pump solids from Irwin Creek WWTP and future Long Creek (Stowe) WWTP to McAlpine Creek WWMF
- McAlpine WWMF – 64mgd, average annual flow ~ 50 mgd, average undigested PS + WAS ~ 50 DTPD

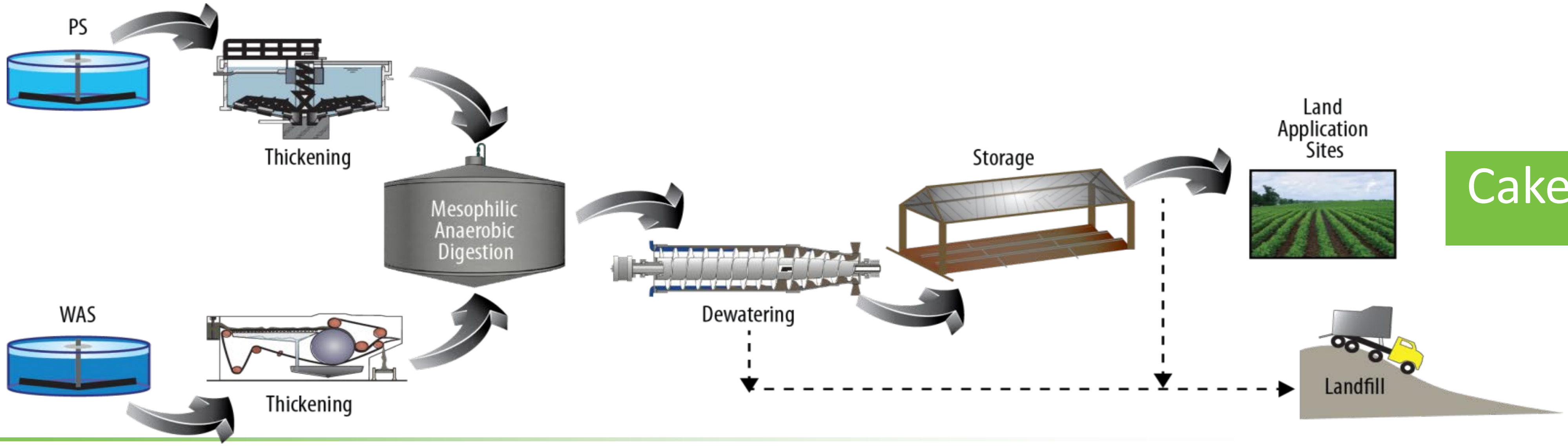


Current Biosolids Management Strategy



Current Solids Treatment Process at McAlpine WWMF

- Gravity thickening of PS from Sugar and McAlpine Creek WWTPs;
- Centrifuge thickening of WAS from McAlpine and Sugar Creek WWTP;
- Anaerobic digestion;
- Centrifuge dewatering of digested sludge; and
- Dewatered cake storage at the onsite Residuals Management Facility (RMF),
- Land application as a Class B product.



Cake, Class B

Current Practice Issues and Challenges

- Existing facilities – aging infrastructure, capacity limitations
- Regulatory and social environment – Fecal regrowth, EPA 503 regulation changes, and public opinion on health and safety
- Limited Outlets – Limited landfill availability and reliability, limited beneficial reuse
- Class B cake solids limitations – limited product densification, increased hauling
- Dependence on single independent contractor

Visions and Goals of the Biosolids Master Plan and Related Projects

Vision: Biosolids Management in a Circular Economy

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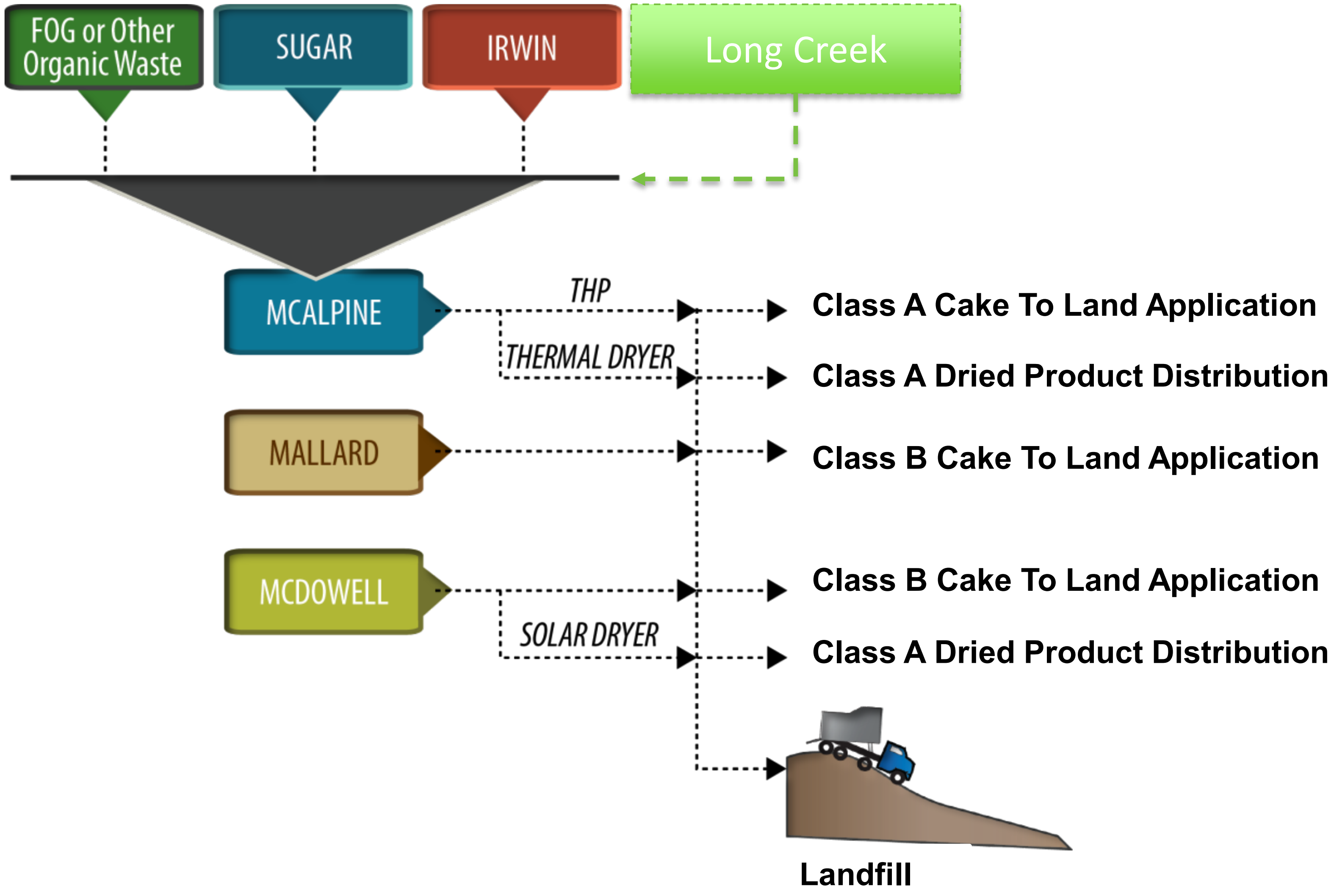
Possible Future Biosolids Management Strategy



Goals of the Biosolids Master Plan and Related Projects

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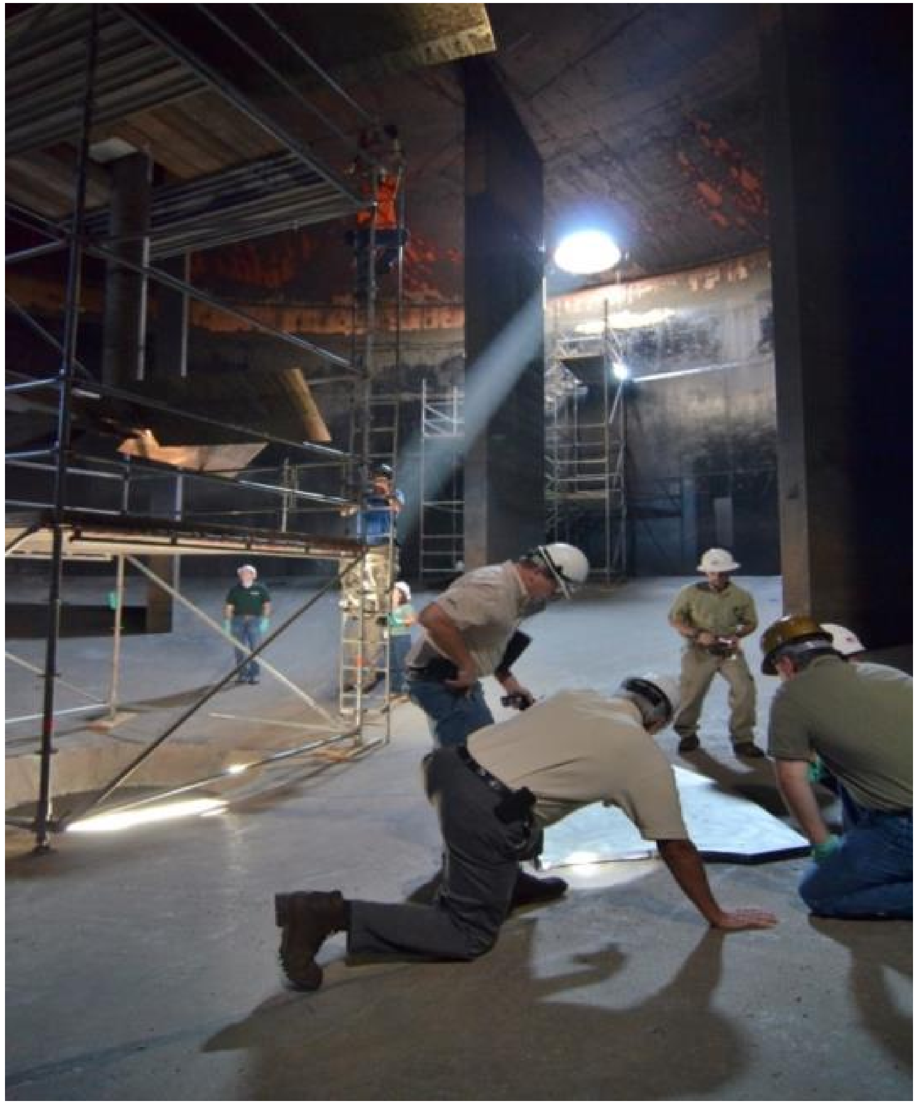
- Goal 1: Optimize Operations through regionalized/centralized biosolids management
- Goal 2: Diversify Products/Reduce Risks
- Goal 3: Update Facilities and Technologies
- Goal 4: Achieve Envision Awards for Related Biosolids Projects

Goal 1: Optimize/Regionalize Operations

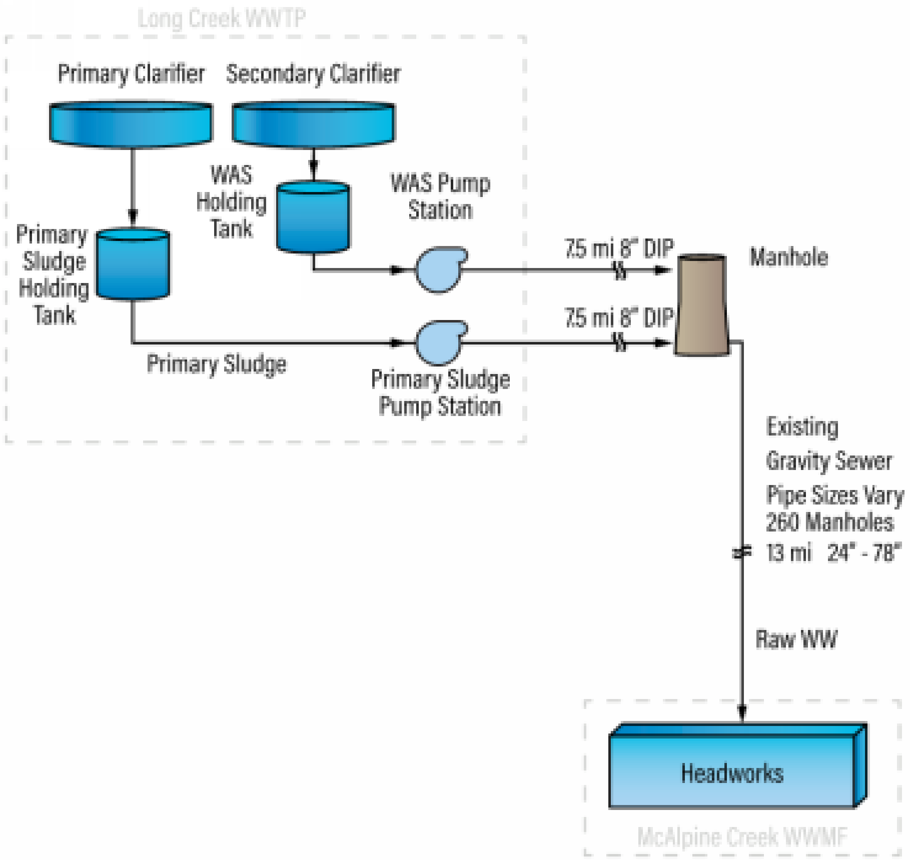
Goal 1 Specific Objective and Strategy

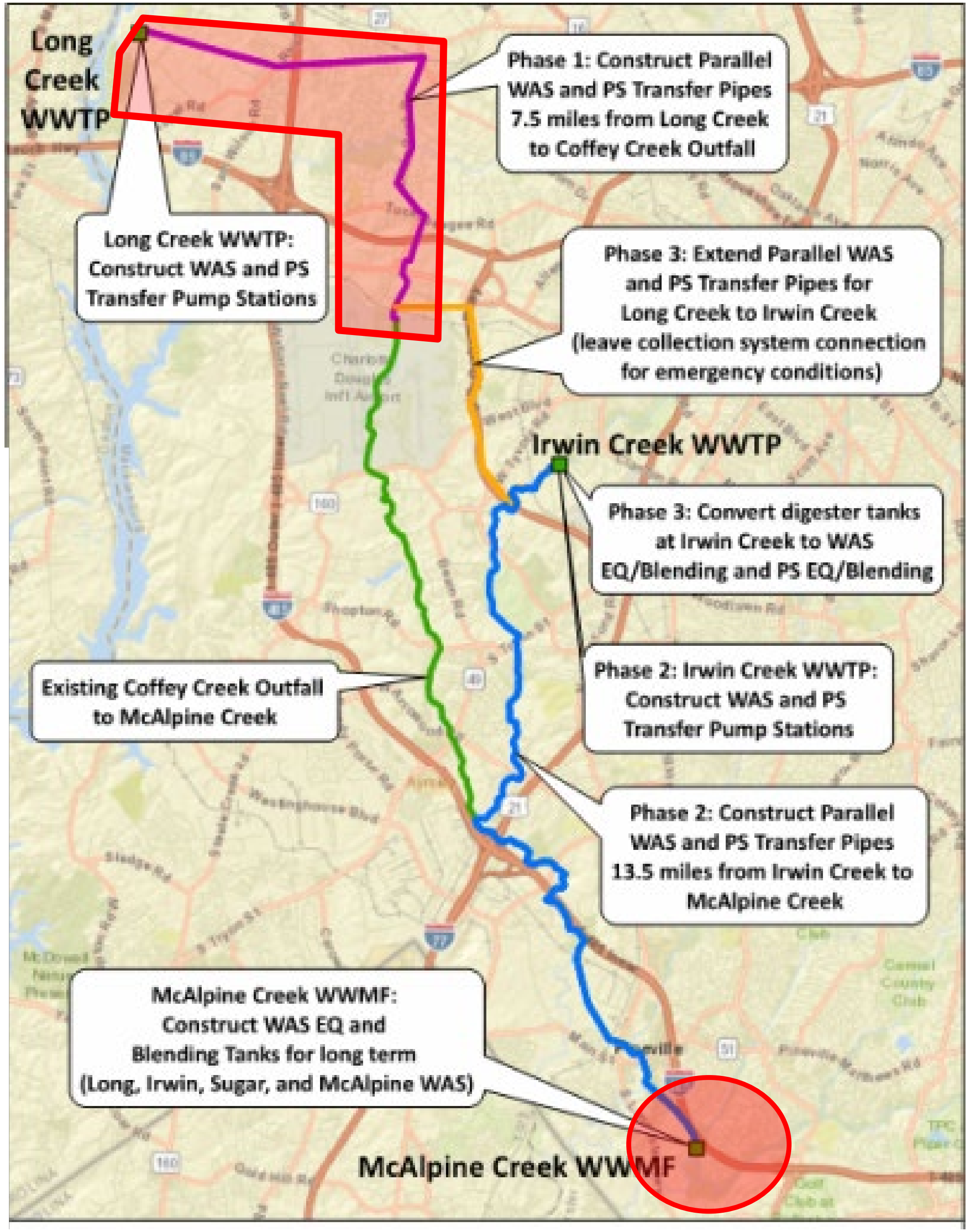
- Objective:
  - Centralize processing - eliminate the need to process solids at future Long Creek and Irwin Creek WWTPs. Process changes/improvements can be done at one plant instead of multiple facilities
  - Streamline operations - consolidate spare parts and operational skillsets (workforce development)
- Strategy :
  - Phased construction of two parallel transfer force mains: one for WAS and other PS; and construction of EQ storage and blending tanks



Phase 1 Forcemains (2023)

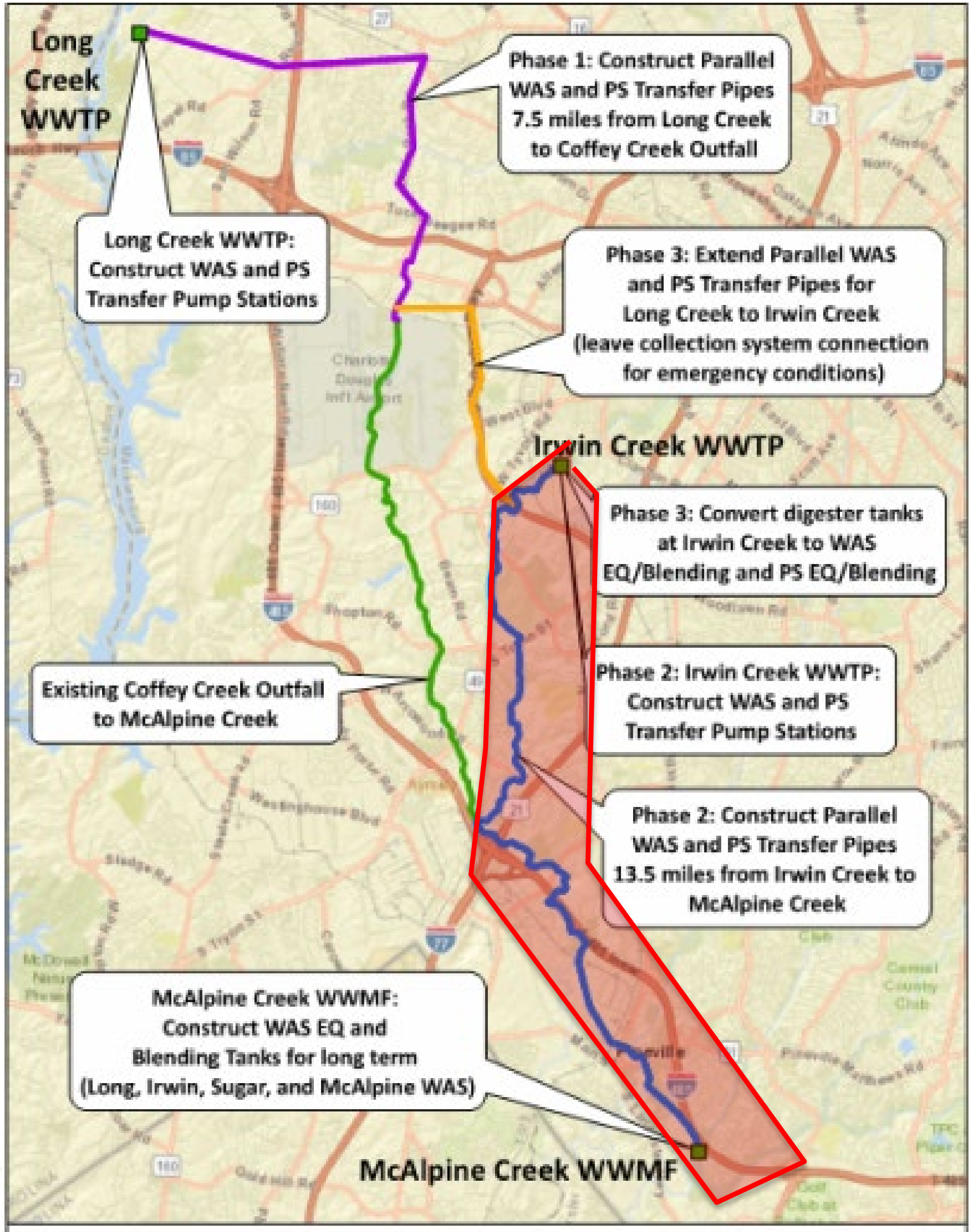
- Pumping station at new Long Creek WWTP (separate project)
- WAS and PS force mains from Long Creek WWTP to gravity sewer system (Active with Long Creek WWTP) - $14 M
- EQ storage and blending tanks at McAlpine WWTP - $7M





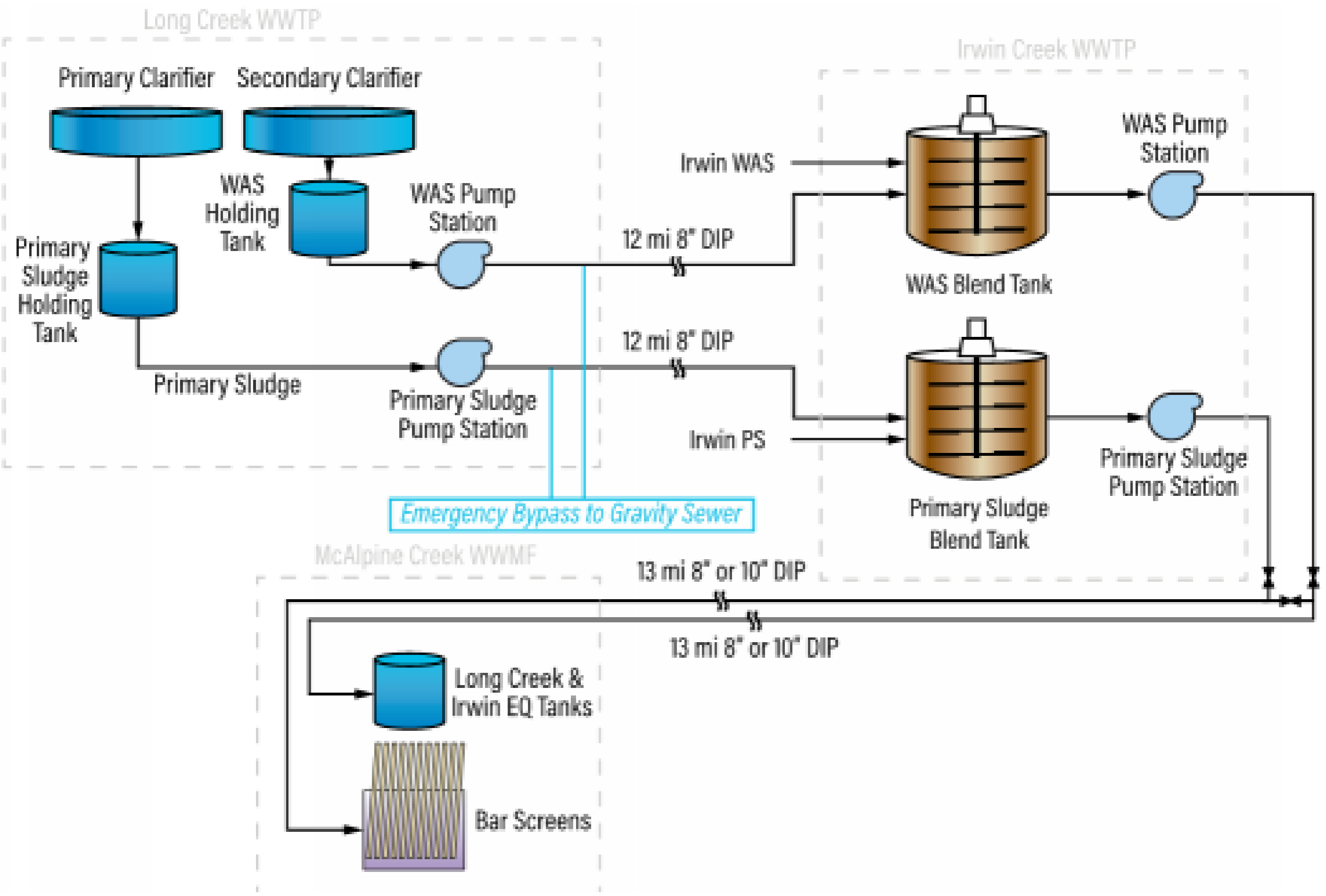
Phase 2 Forcemains (2027)

- Pumping station at Irwin Creek WWTP, and PS and WAS force mains from Irwin Creek to McAlpine Creek WWTP ($31M)
- Option to initiate THP at McAlpine and activate phase 2



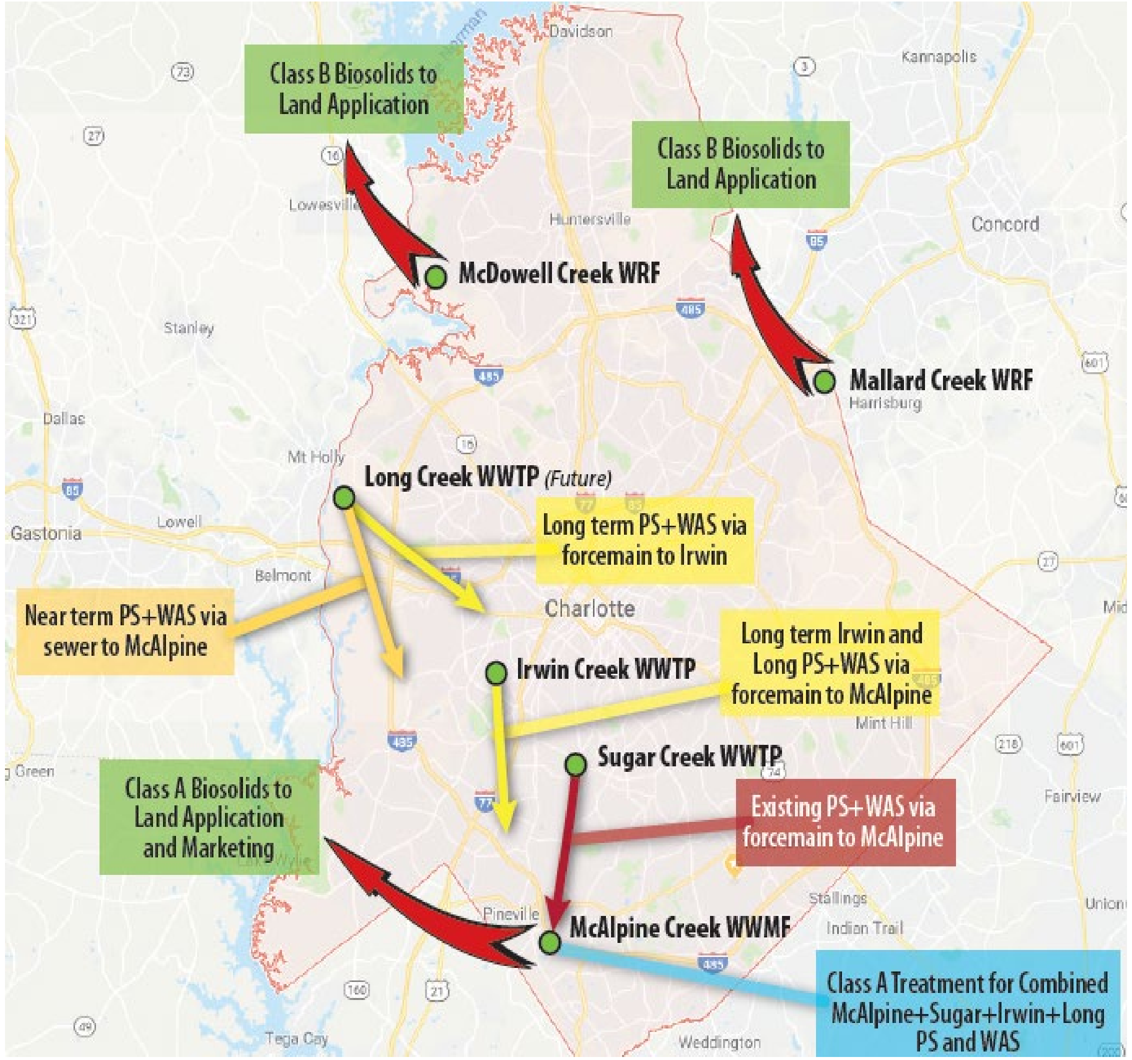
Phase 3 Forcemains (2028)

- Extend the parallel Long Creek WWTP PS and WAS transfer pipes from the gravity sewer manhole to the Irwin Creek WWTP ($11M).
- Conversion of Digesters at Irwin Creek WWTP to WAS & PS EQ & Blending Tanks (1.5M)
- McAlpine Creek WWMF Primary Improvements Solids Receiving Station (new screens etc)



Key Benefits of Centralizing Solids Processing at McAlpine

- Operational efficiency
  - Better utilization of existing digestion and dewatering infrastructure at McAlpine Creek WWMF
  - Consolidation of spare parts and operational skillsets
  - Eliminates the need to process solids at Long Creek and Irwin Creek WWTP
  - Process changes/improvements can be done at one plant instead of multiple facilities
- Opportunities for resource recovery increase with the amount of solids and biogas at one place
- Workforce development and Optimization



Goal 2: Product Diversification and Risk Reduction

Goal 2 Specific Objective and Strategy

- Objective:
  - Flexibility and diversification of biosolids management options
  - Resource recovery in lieu of disposal
- Strategy :
  - Market Assessment:
    - Identifying target markets (biosolids users)
    - Evaluating biosolids alternatives and demand based on user preference
    - Risks assessment for biosolids product selection

Markets Evaluated

- Growers/Agriculture
- Fertilizers/Soil Blending
- Silviculture
- Beautification/Nurseries
- NC Department of Transportation
- Mine reclamation
- Landfills

Biosolids Products

Cake Product

Class A Heat-Dried Pellets

Management Options and Risk Impacts

- Distribution of Class A biosolids
  - If the biosolids treatment process is not able to produce a Class A product, then land application and landfilling are alternative management options.
- Land Application of Class A and/or B on agricultural, forested, or other dedicated sites.
  - If non-conforming to Class B, then landfill.
- Off-site disposal in a municipal solid waste landfill that has been permitted to receive wastewater solids as a viable emergency option for non-conforming Class B products.

The fewer management options available, the more severe the risk impacts.

Risk Assessment

- Risk Inventory
  - A log of risk issues
- Risk Register
  - A re-definition of risks into broader categories to ensure no double-counting
- Market and product risk ranking
  - Assignment of qualitative scoring of risk likelihood and impacts
  - Aggregated impacts of each risk → Risk Priority

$$\text{Likelihood (0 through 4)} \times \text{Impact (0 through 4)} = \text{Risk Priority}$$

$$\sum(\text{Likelihood} \times \text{Impact}) = \text{Product Risk Priority}$$

Product Risk Inventory

- Emerging contaminants, probability of failure to meet regulatory requirements, land application restrictions, and product contamination
- Product acceptance/rejection
- Market oversupply
- Continuity in case of contractor business failure

Risk Probability Scoring Criterion

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Probability Score	Probability/Frequency Likelihood Criterion
0	Risk not applicable for product under review
1	Unlikely/improbable: No quantifiable expectation/potential for occurrence (situation has never occurred previously)
2	Low Possibility: Remote or low potential for occurrence. There is evidence that the risk is possible but highly unlikely to occur (maximum of 1 time in 20 years)
3	Moderate Possibility: Moderate chance of occurrence. There is evidence of this occurring in the past with impacts to the program (potential to occur 2 to 5 times in 20 years)
4	High Possibility: Very likely occurrence or has occurred in the past (potential to occur more than 5 times in 20 years)

Risk Severity Scoring Criterion

Severity Score	Severity of Impact Criterion
0	Risk not applicable for product under review
1	Nuisance impact with no effects on other markets
2	Impact affecting one or more markets with the option to shift to other markets as a result. Low cost impact, low impact to operations
3	Impact affecting all markets with option to shift to landfill as a result. Moderate cost impact, moderate impact to operations
4	Impact affecting all markets and requiring hazardous waste landfill disposal as a result, stranding new assets or otherwise high cost impact that requires use of fund balance that disrupts the Community Improvement Plan(CIP), significant impact to operations

Product Analysis Conclusions

- Interest in biosolids product is strong
- Cost is paramount
- Education is key to expanding market
- Class A products preferred
- Diversification of Class A products beneficial
- Handling of the heat dried pellets easier
- Pellets most desirable option unless spreading would continue to be provided as part of the Charlotte Water Biosolids program.

Product	Total Risk Score
Class B Dewatered Cake	46
Class A Pellet	**27**
Class A Hydrolysis Cake	**30**
Class A Other (e.g. Semi-liquid Product)	36

Goal 3: Update Facilities and Technologies

Goal 3 Specific Objective and Strategy

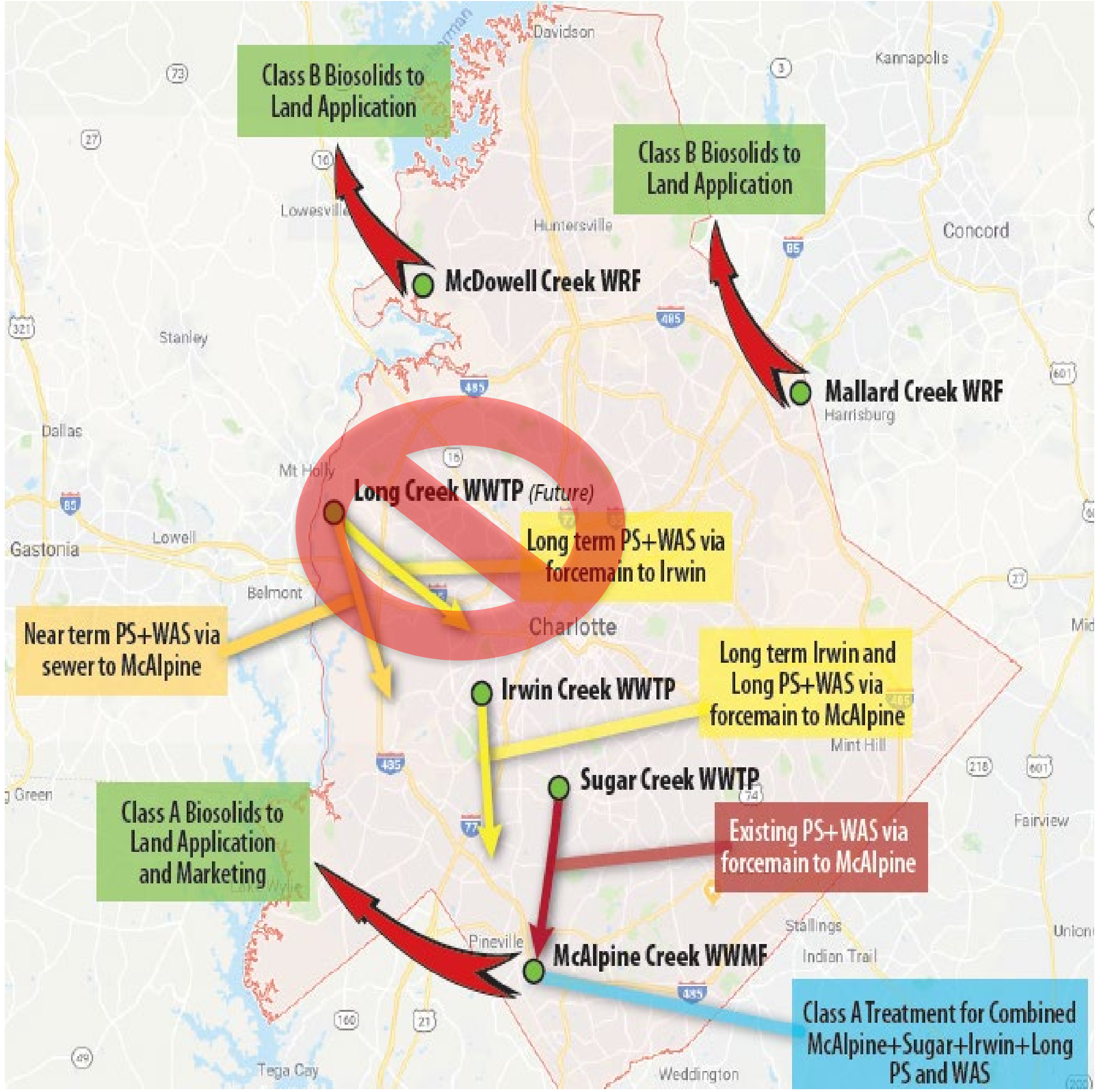
- Objective:
  - Evaluate technology alternatives, including costs analysis and risks assessment, for the various technologies needed to generate products that are similar to those preferred in Market Assessment
- Strategy :
  - Technology Assessment:
    - Technology risks assessment
    - Technology-focused interviews and site visits with multiple utilities nationally and internationally
    - Vetting technologies through sessions with vendors

Technology Assessment – Preliminary Findings

Alternative	Technology
1	**Baseline (maintain conventional anaerobic digestion) –Class B**
2a	Thermo-chemical hydrolysis with lime system and no anaerobic digester enhancement – Potentially Class A
2b	Thermo-Chemical Hydrolysis with lime system and anaerobic digester Enhancement – Potentially Class A
3a	Combination of dewatered cake processing by 3rd party fertilizer processor and Class B, assuming cost of $20/ wet ton – WT ($0.02 per kilogram).
3b	Combination of dewatered cake processing by 3rd party fertilizer processor and Class B, assuming cost of $0/ wet ton – WT ($0.04 per kilogram).
4a	**THP (pre-anaerobic digestion) – Class A**
4b	THP (inter anaerobic digestion) – Class A
4c	THP (post anaerobic digestion) – Potentially Class A
5a	**Thermal Drying 100% of 2040 Max Month Solids Loading – Class A**
5b	Thermal Drying 50% Solids (Class A) and retaining 50% Class B Cake

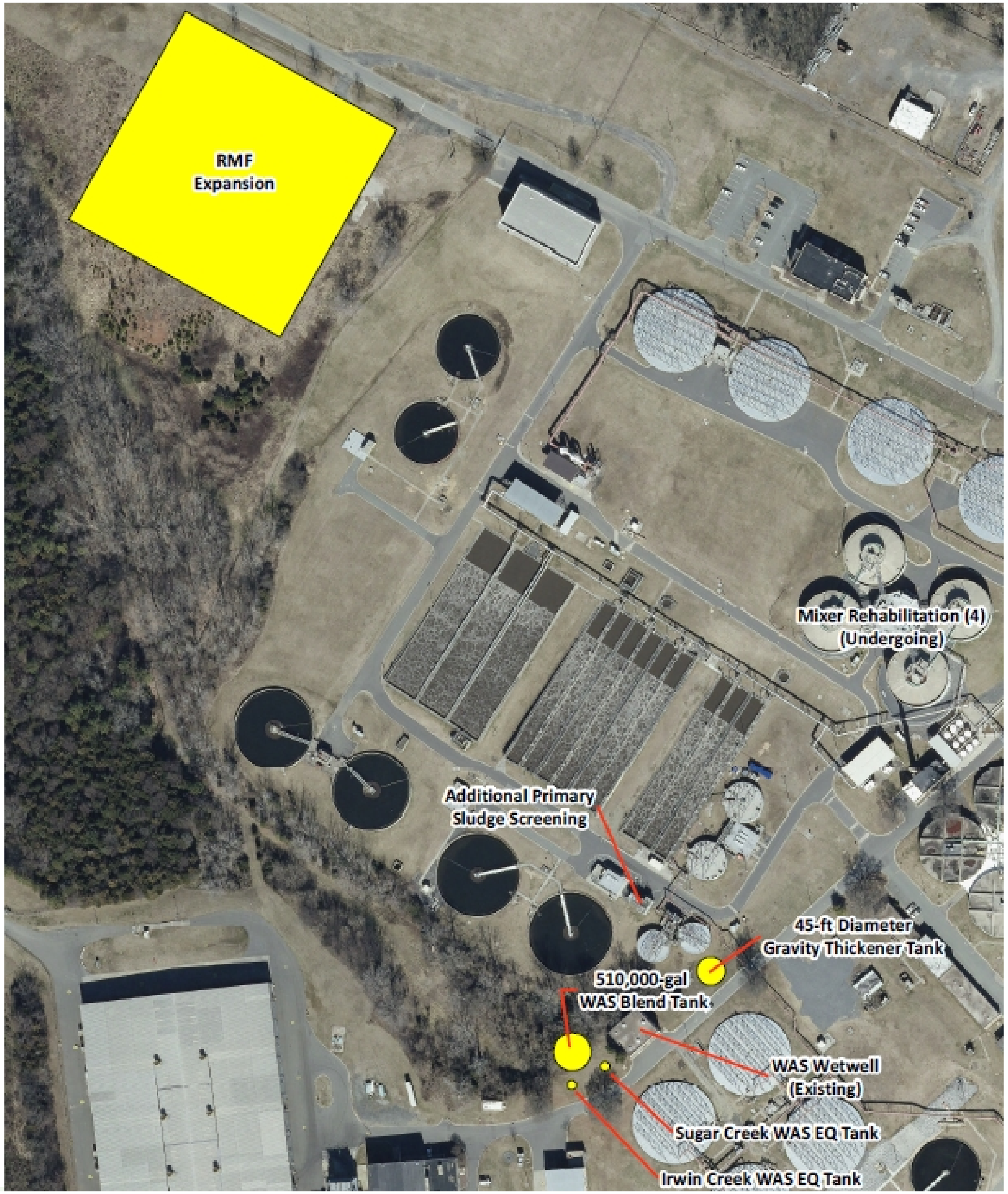
Alt 1: Baseline (maintain conventional anaerobic digestion)

- Assumes no solids transfers from Long Creek
- Maintain digestion and dewatering at McAlpine Creek WWMF
- Construct Long Creek WWTP Solids Facilities
- Treat Irwin Creek Solids at McAlpine



Baseline - Operational and Facility Changes

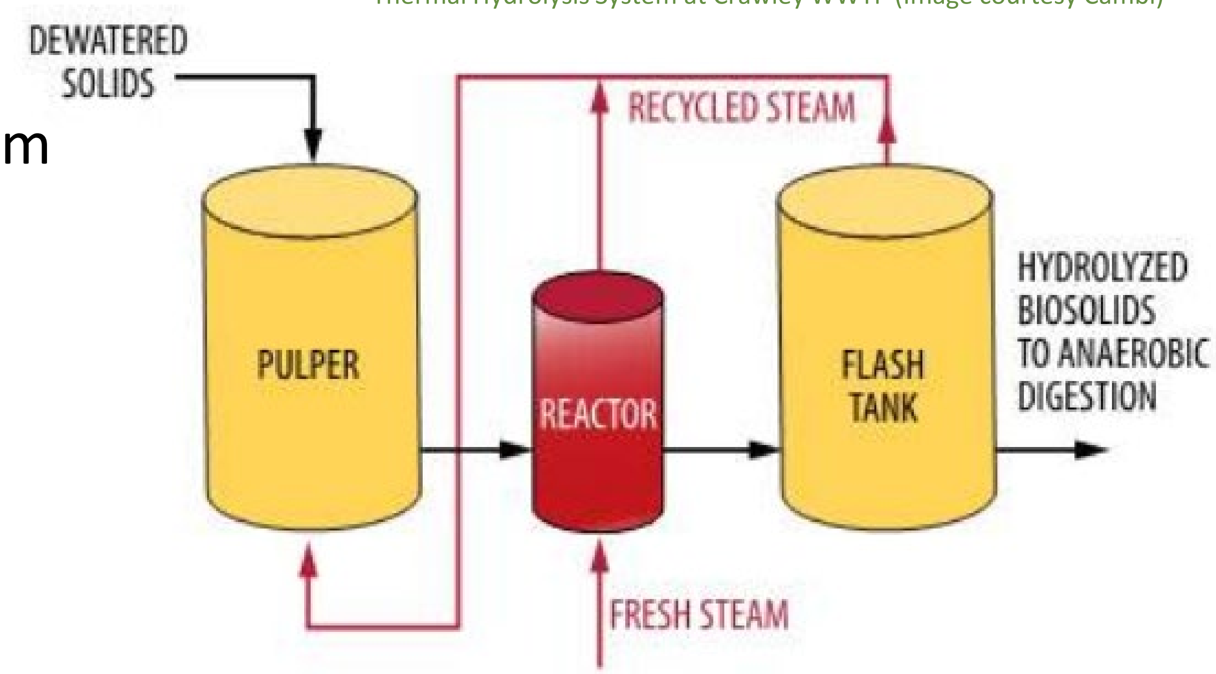
- Additional equipment and facility upgrades required due to increased class B cake from Irwin and projected growth increases
  - New PS gravity and centrifuge thickeners
  - New Sugar, and Irwin WAS EQ and blending tanks
  - New PS screens
  - Additional biosolids storage
- Thickening/dewatering complex upgrades
- Phosphorus recovery system



Alt 4a- THP (pre-anaerobic digestion) – Class A

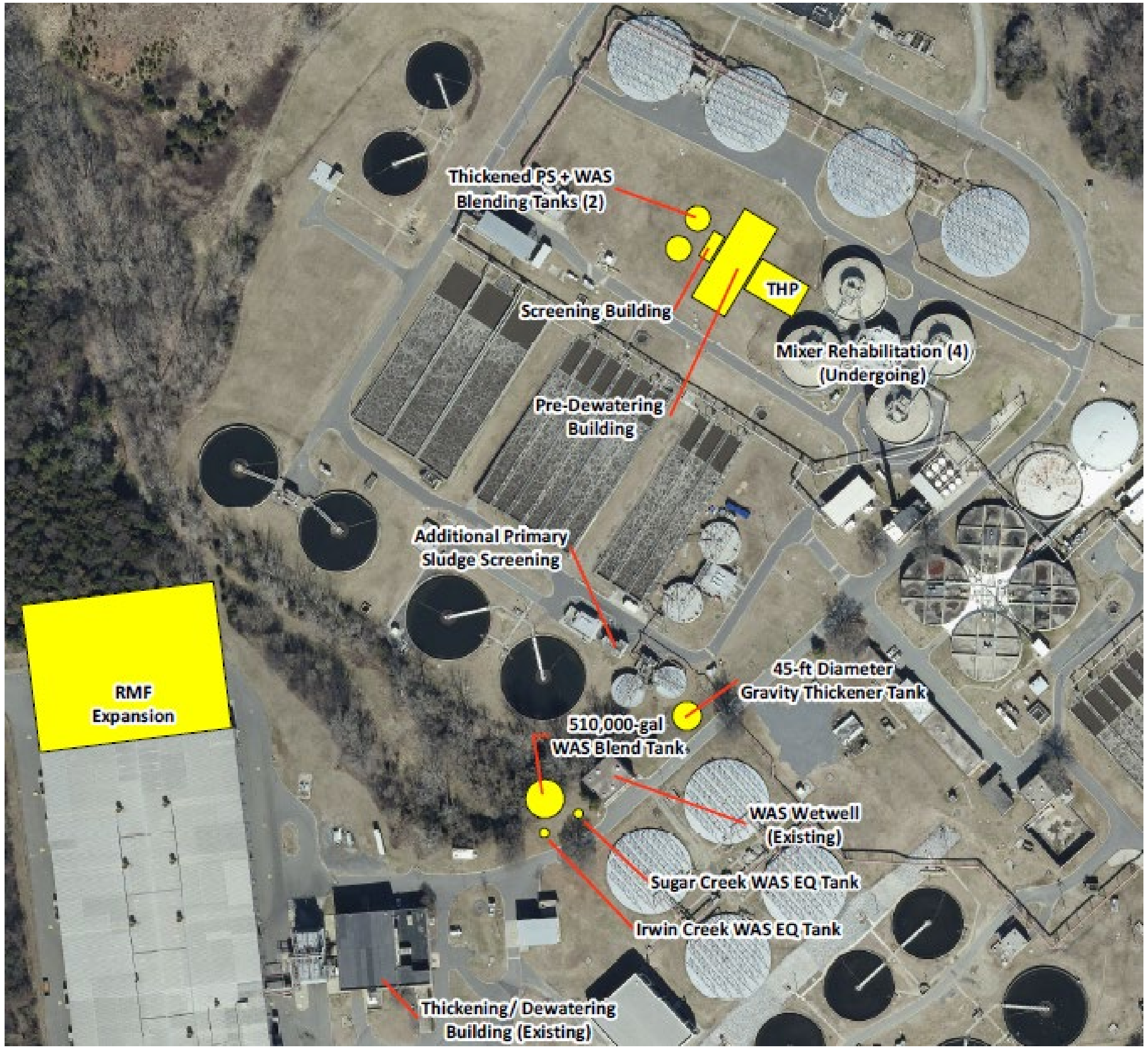
- THP breaks down cell walls, hard to digest compounds, by application of high pressure (90psi) and temperature (330 F), for about 20 minutes.
  - Reduces viscosity of material
  - Destroys pathogens
  - Improves bioavailability of nutrients
- Pre-anaerobic THP - THP located upstream of the anaerobic digestion process
  - Increases digester solids loading
  - Higher VSR, resulting in fewer residual solids and optimized biogas production
  - Improved post-digestion dewatering performance with drier cake.

Thermal Hydrolysis System at Crawley WWTP (Image courtesy Cambi)



THP (pre-anaerobic digestion) – Class A

- Solids transferred from Irwin Creek will be blended with sludge from the proposed Long Creek WWTP.
- THP Operational and Facility Changes include:
  - THP system
  - PS + WAS blending tank required in addition to the WAS blending tanks
  - Screening Building and PS+WAS screens
  - Pre-dewatering building, pre-dewatering centrifuges and sludge hoppers



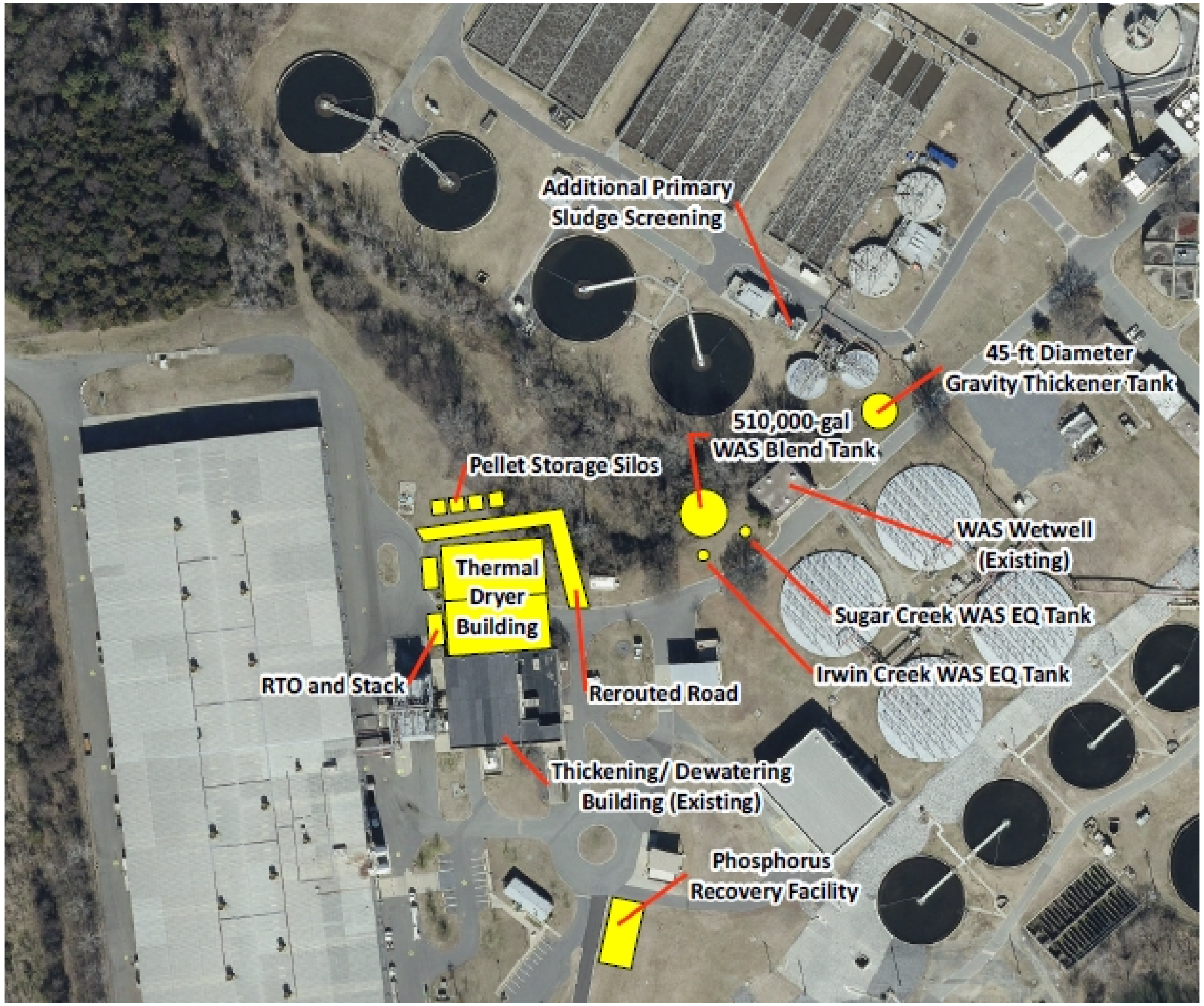
Thermal Drying – Class A

- Implement thermal dryers for 100% solids loading at McAlpine Creek WWMF
- Solids transferred from Irwin Creek will be blended with sludge from the proposed Long Creek WWTP.
- Installation downstream of digestion and dewatering
- The rotary drum dryer was the only type of dryer evaluated in detail.
  - It is the most prevalent drying technology at medium to large facilities in the U.S

Dryer at Winston Salem

Dryer Operational and Facility Changes

- Dryer system including feed hopper, furnace, etc.
- Air quality and potential noise control
- Dryer Building
- Pellet Storage Silos



Technology Risk Inventory

- Considered Quadruple Bottom Line/4P Approach:
  - **P**eople: Product Distribution and marketability, nutrient content, product densification – transportation, ease of spreading and application restrictions
  - **P**lanet: Environmental sustainability - Permitting and Emission, fuel/energy demand, water demand, dust, noise, utilization of existing equipment/facilities or expansion requirements, footprint requirements, side stream treatment requirements.
  - "**P**rofits" or costs and offsets: Capital and maintenance costs/life cycle cost.
  - **P**rogress in Technology: Technology maturity and complexity – Safety, maintainability, ease to operate, staff and training requirements, parts availability, technical expertise/competencies/support resources.

Biogas Production with THP-AD

- Assumes biogas production of 10.5 to 15 standard cubic feet (SCF) per pound volatile solids reduction (VSR).
- Assumes biogas energy content of 585 BTUs per SCF.

Comparison of Energy Balance (MMBTU/day) with THP and Dryer and with Dryer Alone

THP and Dryer

Year	Energy produced from THP AD	Energy required for THP	Energy required for drying	Total energy required for THP and drying	Energy balance
2025	767	254	300	554	**213**
2040	997	332	392	724	**273**

Only Dryer

Year	Energy produced from AD	Energy required for AD	Energy required for drying	Total energy required for AD and drying	Energy balance
2025	660	239	692	931	-271
2040	858	305	904	1209	-351

Carbon/GHG Emissions

- Considers dependency on fossil fuels and resulting emissions in biosolids processing and hauling.
- THP alternatives have net negative GHG emissions due to the increase in biogas production and ability to use this biogas to offset consumption of other fossil fuels.

Alternative	Updated Net GHG Emissions (MT CO2e/year)	Equivalent To…			
		Passenger Vehicles (Vehicles / Year)	Passenger Vehicle Miles (Miles/Year)	Home Electricity Use (Homes/ Year)	Smartphones Charged (Phones/ Year)
Class B	5,900	1,250	14,400,000	1,030	753,000,000
THP	-2,400	-510	-5,900,000	-420	-306,000,000
THP w/Dryer	4,200	890	10,300,000	730	536,000,000
100% Dryer	27,800	5,900	68,000,000	4,850	3,546,000,000

Cost Analysis Summary

- Life cycle cost computed over 20 years (2021 to 2040)
- Life cycle cost = Capital cost + O&M NPV (2018-dollars)
- O&M includes annual equipment and facilities maintenance costs, labor, fuel/electricity cost, polymers and other chemicals, and biosolids distribution/disposal costs.

	Baseline Maintain Digestion & Dewatering at McAlpine Creek WWMF, Construct Long Creek WWTP Solids Facilities, Convey Irwin Creek WWTP Solids to McAlpine Creek WWMF for Treatment	THP - Implement THP at McAlpine Creek WWMF, Convey Long Creek and Irwin Creek WWTP Solids to McAlpine Creek WWMF for Treatment	Dryer - Implement 100% Thermal Drying at McAlpine Creek WWMF, Convey Long Creek WWTP Solids to McAlpine Creek WWMF for Treatment
Total Capital Cost	$55 M	$179 M	$203 M
Total Net Present O&M Cost	$98 M	$147 M	$234 M
Total Present Worth Cost	$153 M	$326 M	$435 M

Dryer Site Visit and Meeting with Utility Operators/Owners in the U.S

- Archie Elledge WWTP Drying Facility (Andritz Rotary Drum Dryer)
- Mooresville WWTP Dryer Facility (Drum Dryer)
- Gryphon Environmental/Tyson Facility, Owensboro, KY (Low Heat Belt Dryer System)
- Milton Wastewater Treatment Plant Drying Facility, Milton PA (Andritz belt Dryer).

EU Site Visits and Meeting with Utility Operators/Owners

- Ringsend WWTP, Dublin, Ireland – Cambi THP, CHP, Drum Dryer post THP
- Crawley WWTP (Thames Water), UK (50% sludge imports) – Cambi THP and CHP
- Oxford WWTP, UK (50% sludge imports)- Veolia THP
- Mondelez Food Plant, Brussels, Belgium – Veolia Dynamic Mixer

Phone interviews/questionnaires with Utility Owners/Operators

- Thames Water, UK (Veolia and Cambi THP, Dryers)
- Louisville Metropolitan Sewage District, Louisville, KY (Andritz Retrofitted Drum Dryer, planning to switch to THP)
- Trinity River Authority of Texas, Dallas, TX (Cambi THP w/AD – start-up late 2021)
- City of Raleigh, NC (Cambi THP w/AD, regionalization, start-up early 2022)
- City of Franklin Water Reclamation Facility, Franklin, TN (Cambi THP w/AD, regionalization – startup 2021/22, future plans to install solar dryer)
- Hampton Roads Sanitation District; Atlantic Wastewater Treatment Plant, Virginia Beach, VA (Cambi THP – start-up early 2022)
- DC Water; Blue Plains Advanced Wastewater Treatment Plant – (Cambi THP W/AD)

Dryer – Advantages and Disadvantages

Advantages	Disadvantages
• Established technology with many installations • Produce product at 90% or more dryness, with max. volume reduction • Transportable product not limited to local market • Good quality product can produce revenue to offset some operating cost	• Huge energy required to evaporate water • Complex, highly mechanical system required to produce high quality product • Some newer drying systems are less mechanical, but at the expense of product quality • Operation and maintenance of drying system requires special training • Excessive maintenance requirements for some drying systems have been reported • Dust from the dried product is a fire and explosion hazard • Greenhouse gas emissions

THP – Advantages and Disadvantages

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Advantages	Disadvantages
• Process pretreats the sludge for more complete digestion and stabilization • Treated sludge requires less digestion capacity to digest, freeing up valuable capacity to treat additional sludge or other wastes • More complete digestion results in more biogas production and less residuals solids to be handled downstream • Digested biosolids has much better dewatering characteristics, resulting in drier cake (30% + comparing to current 20% or less) • Finished product is drier, and almost odor free. • Potential for a net negative GHG emission technology. • Plug and play operationally	• Not as established in the U.S., with one operating facility, although 5-6 more are under construction • Process requires steam generation, which is a new process at the plant • Pressure vessels also require periodic inspection • An additional dewatering step is needed to feed the process • Due to better digestion, a strong sidestream will be produced which will need to be handled

Preliminary Results Leaning towards THP Implementation

- Aligns with City of Charlotte's goal to be carbon neutral by 2050. THP has net negative GHG emissions in comparison to dryers, which have an estimated emission of 27,800 metric tons CO_2 equivalent/year – compare this with emissions from driving 68 million miles/year.
- Lower life cycle cost- $100 million lower than thermally dried without THP.
- Net positive energy, with biogas production adequate for both THP and thermal dryer energy needs. Does not depend on natural gas. No fluctuations in O&M costs based on natural gas pricing.
- Provides more flexibility for future treatment alternatives (dryer can be added downstream of THP-AD in future).
- Increased anaerobic digestion capacity facilitating regionalization efforts. THP-AD extends the capacity of the existing digestion assets, allowing the possibility of accepting imported organic wastes to further enhance biogas production in the digesters.

Possible Improvements based on Preliminary Results

McAlpine

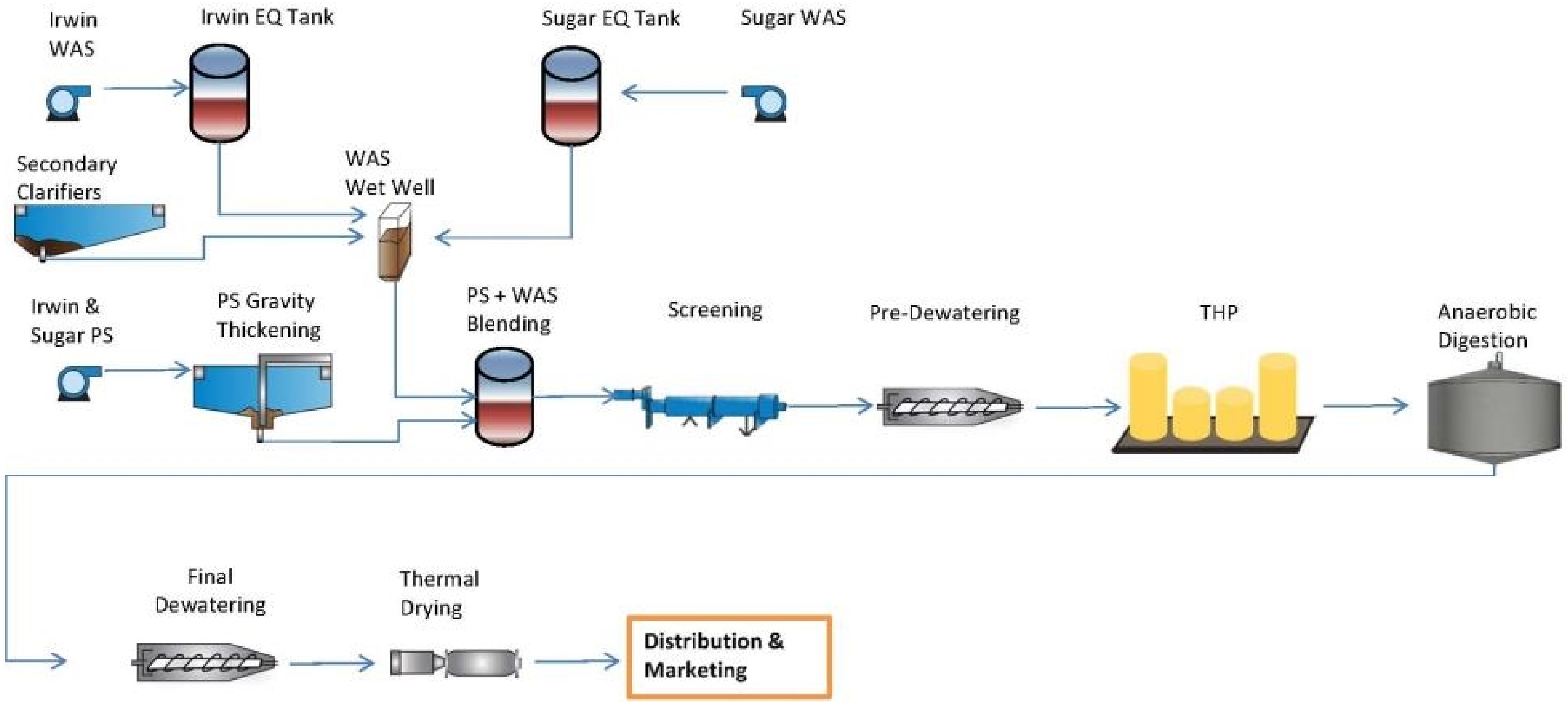
- Thermal Hydrolysis and/or Thermal Drying

Irwin

- Pump to McAlpine

Mallard & McDowell

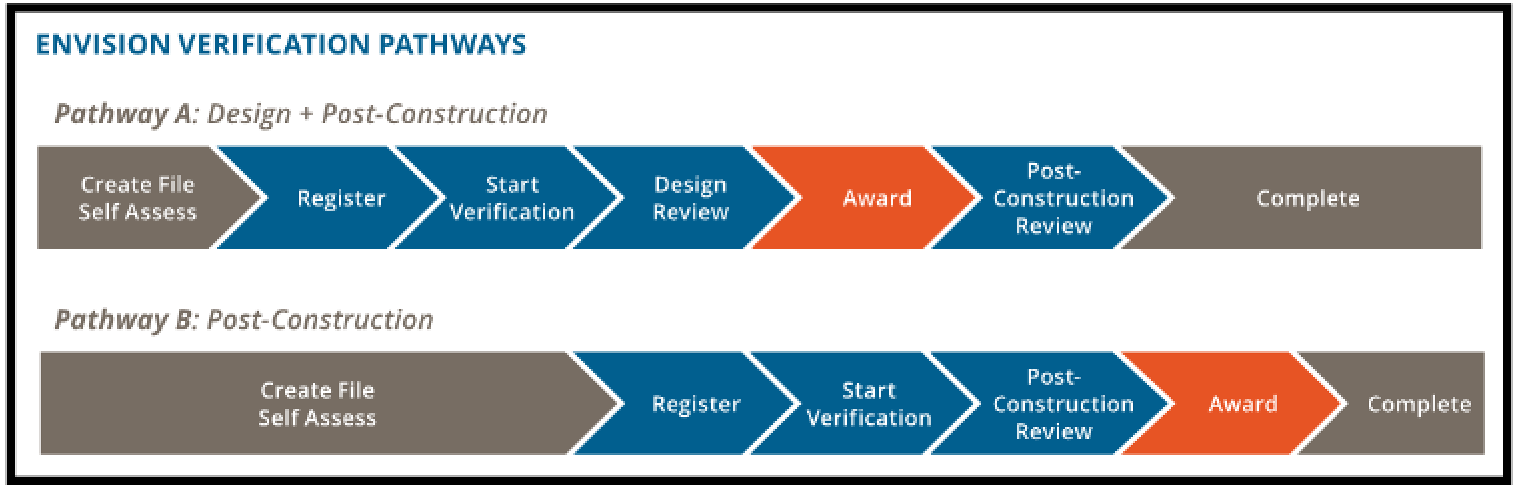
- Maintain current operations
- Potentially implement solar dryers at McDowell



Goal 4: Envision Award for Related Biosolids Projects

Goal 4 Specific Objective and Strategy

- Objective:
  - Obtain two envision awards, one for the conveyance project and the other for the plant improvement project
- Strategy :
  - Pathway A: Earn an Envision award after design completion. Constructed project validated to determine if it still meets award requirements.



Envision Considerations

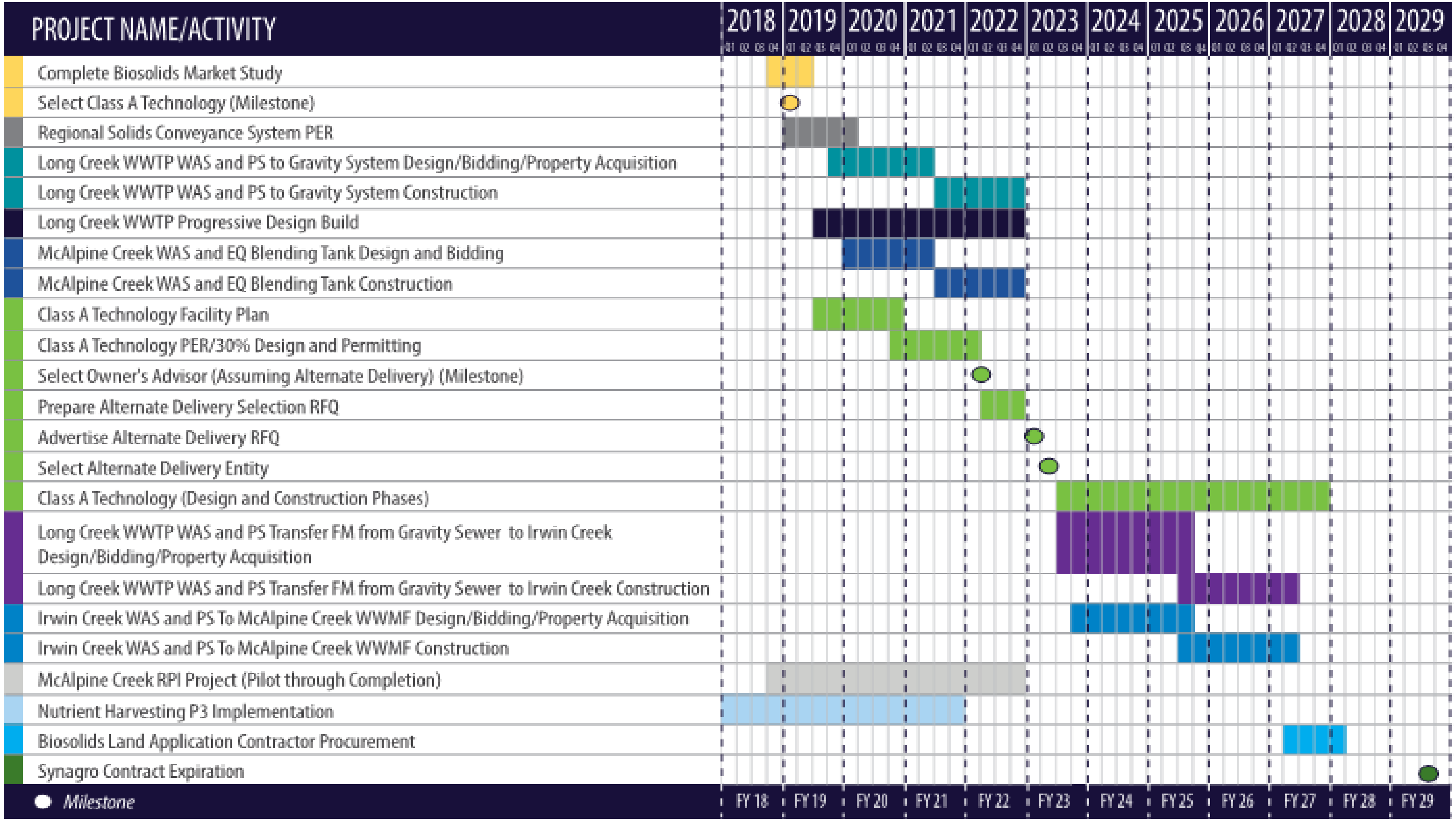
- Envision is a rating system for civil infrastructure by which projects are measured and awarded on their degree of sustainability.
- Focuses on sustainable and resilient design, construction and maintenance of non-habitable and horizontal infrastructure that are not eligible for LEED certification, such as pipeline and WWTP projects.
- Will capture and showcase our Sustainability Mission/Vision statement
- May reduce stigma associated with biosolids reuse
- May enhance marketability of Class A products
- Relatively "easy/ideal" project: Reuses what others might consider "waste"; reduces fertilizer impacts; recycles material/equipment/structures (digesters at Irwin; gravity sewer for solids transfer); THP boost biogas production → reduces greenhouse gas emission etc.

Preliminary Implementation Schedule

Preliminary Implementation Schedule

- Next 5 years
  - Complete facilities planning at McAlpine Creek WWMF
  - Complete technology evaluation and selection
  - Complete sludge conveyance projects
  - Implementation of Long Creek WWTP to Gravity FM (Phase 1)
  - Class A Technology Facility Planning and Permitting

Preliminary Implementation Schedule



Discussion

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