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Environmental Engineers & Scientists

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Subject:
Executive Summary
Wastewater Treatment Capacity and Effluent Disposal Study
Murfreesboro Water and Sewer Department

Introduction

The City of Murfreesboro is faced with several challenges for expanding and upgrading their wastewater infrastructure. A growing population, an aging collection system, and environmental limitations on surface water discharges have complicated the planning process for the next wastewater capacity expansion. In the last ten years, population growth in the city limits and rise in demand for services inside the City's urban growth boundary have contributed to the increase in wastewater flow.

Sinking Creek Wastewater Treatment Plant

The Sinking Creek Wastewater Treatment Plant (WWTP) is owned and operated by the Murfreesboro Water and Sewer Department (MWSD), and is the only wastewater treatment facility serving the City. The plant is permitted for a surface water discharge of 16 million gallons per day (mgd) to the West Fork of the Stones River and is currently operating above 80 percent of its rated design capacity. Treated effluent from the Sinking Creek WWTP is also routed to the City's non-potable repurified effluent disposal system that meets beneficial reuse standards. The repurified water is either land applied at a dedicated disposal site (Jordan Farm) or conveyed to a growing list of reuse customers for site irrigation or other repurified water uses.

The City commissioned Hazen and Sawyer in June 2010 to evaluate potential wastewater treatment expansion and effluent disposal alternatives. This *Wastewater Treatment Capacity and Effluent Disposal Study* evaluates population growth and distribution, regulatory requirements for effluent disposal, wastewater treatment technologies, effluent disposal options, centralized versus decentralized wastewater treatment alternatives, the collection system infrastructure, and capital and operation and maintenance

(O&M) costs. The evaluation in this study ultimately directed the development of a comprehensive set of wastewater treatment solutions to address near and long-term planning requirements.

Seven Technical Memorandums (TMs) provide the evaluation for each of the major parts of the study, as follows:

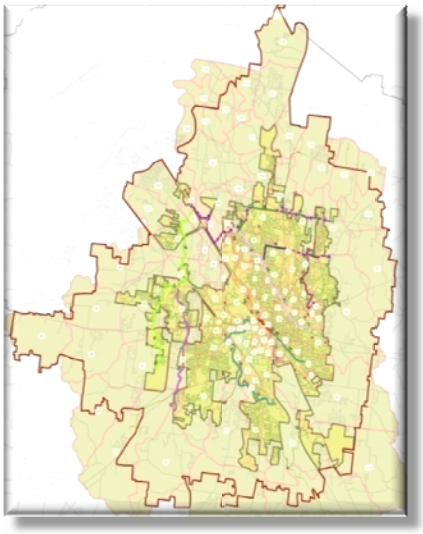
- Technical Memorandum #1: Population and Wastewater Flow Projections.
- Technical Memorandum #2: Regulatory Analysis.
- Technical Memorandum #3: Evaluation of Treatment Technologies.
- Technical Memorandum #4: Effluent Disposal Options.
- Technical Memorandum #5: Centralized / Decentralized Treatment Alternatives.
- Technical Memorandum #6: Collection System Evaluation.
- Technical Memorandum #7: Capital Improvements Recommendations.

The following sections describe the primary objectives of each TM, provide a brief description of the technical evaluation, and discuss any action items or recommendations to be used in the planning process.

Technical Memorandum 1 – Population and Wastewater Flow Projections

TM 1 provides an evaluation of the current and projected geographical population distribution and corresponding wastewater flow in the City's planning area. A twenty-year planning period (2010 – 2030) was evaluated in five year increments. Dry and wet weather flow was also considered, as well as an evaluation of peaking factors.

The total population in the service area was differentiated from the actual population served by MWSD. The MWSD urban growth boundary is comprised of 123 sewer districts. The sewer districts delineate the boundaries of the City's current and future services planning area. The City does provide sewer service to the majority of residents and businesses in the city limits, with the balance being served by septic systems. The City's policy is to keep those areas on septic systems unless a significant problem arises. The City also serves areas outside the city limits but within the sewer district boundaries. Other customers within the urban growth area are either on septic systems or are served by the Consolidated Utility District.



City of Murfreesboro Sewer Districts

The growth potential for each sewer district was determined based on the area available for future growth within each district,

current zoning classifications, and active subdivisions. Population growth was determined to be greatest southwest of I-24 and northeast of Murfreesboro center-city. Approximately 110,000 persons are currently served by MWSD compared to approximately 180,000 persons living in the urban service area. By 2030, MWSD is expected to serve 184,000 compared to 313,000 total persons in the urban growth boundary.

In addition to the development of wastewater flow projections, plant monitoring data from January 2007 through June 2010 data were examined to develop baseline annual average daily flow, maximum month flow, and instantaneous (e.g., hourly) peak flow. The 2010 annual average flow and maximum month flow are 16.2 and 21.9 mgd, respectively. The City has maintained a flow monitoring network for several years to evaluate infiltration and inflow (I/I), so peaking factors were calculated for each sewer district at all permanent flow monitor locations. The maximum month to annual average flow ratio was determined to be 1.35. The peak day to annual average peaking factor ranged from 2.50 to 6.59. For districts not served by a flow monitor, a maximum month to annual average daily flow factor of 1.1 and a peak day to average annual daily flow factor of 2.5 was assigned.

Wastewater flow projections were developed based on the population projections and residential and non-residential demands in the study area in five year increments through 2030. Residential flow was projected by multiplying the served population using a residential per capita rate of 130 gallons per person per day (gpcd). Non-residential flow was estimated at 8.3 percent of non-residential meters to residential water meters calibrated to total residential flow and adjusted as necessary within each sewer district to account for large users and/or predominantly non-residential districts. The total projected wastewater flow for the area served by MWSD in 2030 was estimated to be 27 mgd, 39.5 mgd, and 85.1 mgd for average day, maximum month, and peak day flow, respectively.

Technical Memorandum 2 – Regulatory Analysis

There are significant regulatory constraints associated with new or expanding surface water discharges in Rutherford County. Additional surface water discharges could be provided by either the expansion of the Sinking Creek WWTP or the construction of a new satellite treatment facility. Rutherford County is predominantly characterized by low flow and/or impaired streams. Impairment status is due to bacteria (*Escherichia coli)*, nitrate and nitrite, phosphorus, loss of biological integrity due to siltation, or low dissolved oxygen. The pollutant sources include municipal point sources, agricultural use, or livestock grazing operations. The Tennessee Department of Environment and Conservation (TDEC) has developed total maximum daily loads (TMDLs) for several stream segments in the county. The remaining stream segments are prioritized for pending TMDL development; however, TDEC has classified the West Fork Stones River adjacent to the existing outfall as a low priority, which is equivalent to a 12 year timeframe for TMDL model and limits development.

In 2010, MWSD explored new and expanded surface water discharge effluent disposal strategies with TDEC. At that time, seven surface water discharge strategies were presented to TDEC for an initial assessment. TDEC responded that three of the seven strategies are potentially viable:

1) A seasonal expansion of the existing discharge into West Fork Stones River at Outfall #001.

2) A new continuous discharge into East Fork Stones River at proposed Outfall #002.
3) A new satellite WWTP with a seasonal discharge into East Fork Stones River at proposed Outfall #002.

TDEC has indicated that an expanded seasonal surface water discharge in the West Fork Stones River may be viable during periods when the river flow exceeds the minimum river flow and pollutant loadings are maintained at or below the current permitted threshold.

An expansion of the Sinking Creek WWTP would need to result in a lower target nitrogen and phosphorus concentration in order to maintain the fixed pollutant load thresholds to the West Fork Stones River. Other oxygen-consuming pollutants, such as carbonaceous biochemical oxygen demand (CBOD) and ammonia, could potentially be affected by a fixed threshold. The current CBOD and ammonia limits are extremely stringent and a reduction in the limits would increase the risk of permit excursions. It could also be argued that ammonia and CBOD should not be considered contributory to the overall impairment status of West Fork Stones River. The permitted target effluent total nitrogen concentration for the facility is 9 mg/l. The existing plant permit requires only that total phosphorus be monitored, but the plant reliably achieves an effluent concentration of 4 mg/l.

During the course of the current study, several discussions were initiated with TDEC. One major topic of discussion with TDEC was the design parameters and differences associated with land application by either spray or subsurface drip irrigation as alternative effluent disposal options to a surface water discharge. The regulations associated with land application involve maximum application rates, seasonal restrictions, treatment requirements, nitrogen uptake of the receiving crop, soil-types, and wet weather storage requirements. A major difference between the regulations associated with spray and drip irrigation is that spray irrigation is not allowed during rain or snow/ice events, so wet weather storage is required. Drip irrigation systems may theoretically be used for the entire year. Additionally, unrestricted sites open to public access in both spray and drip irrigation regulations require higher quality effluent standards than restricted sites closed to public access. Therefore, treatment options that produce a higher effluent quality should be considered to maintain maximum flexibility in serving beneficial reuse customers in the region.

Technical Memorandum 3 – Evaluation of Treatment Technologies

Several advanced treatment technologies are available for the expansion of the Sinking Creek WWTP or the construction of a decentralized, or satellite, treatment facility. Six treatment technologies were evaluated in this TM: extended aeration oxidation ditches, plug flow conventional activated sludge reactors, membrane bioreactors (MBR), integrated fixed-film activated sludge (IFAS), moving bed biological reactors (MBBR), and sequencing batch reactors (SBR). General process

Oxidation Ditch at the Sinking Creek Wastewater Treatment Plant

descriptions, applications, advantages and disadvantages, design criteria, and unit cost estimates were provided for each technology using pilot studies and previous research as references. A discussion of sidestream treatment, wet weather treatment, and biosolids handling and disposal were also addressed.

The six treatment technologies provide a wide and overlapping range of effluent quality. The results indicate that there are several factors to consider during the selection of a treatment technology for a particular application: a plant's influent characteristics, the effluent limits specified in the permit, the treatment reliability and redundancy required to consistently achieve permit limits, flexibility and adaptability of the system, operability, energy efficiency, capital costs, operation and maintenance costs, the potential for future regulatory action, and physical constraints (size of facility, land availability, etc.). All six technologies have been used for both surface water discharges and reclaimed water use applications in the United States.

Example of Flat Plate Membrane Module

Inherent with each technology are advantages and disadvantages to the process and/or operation and maintenance. Effluent requirements are usually the primary factor in the selection of a treatment technology (e.g., advanced nutrient removal); however, more than one treatment technology could be applicable to a particular situation. In this case, capital and operation and maintenance costs should be factored into the selection of a treatment process or technology. Other non-monetary factors are considered, such as process flexibility and ancillary treatment needs (e.g., influent equalization).

The capital required to construct a project depends on several factors, including redundancy in equipment, process flexibility, the number of buildings, architectural design, economic conditions, and owner preference. The results of the capital and operating cost comparison in this TM indicate that construction costs are generally less for activated sludge systems with nitrification and tertiary filtration, followed by activated sludge with advanced biological nutrient removal processes. Membrane bioreactors with advanced biological nutrient removal are generally associated with the highest construction costs per gallon when compared to other technologies.

Illustration of an Integrated Fixed-Film Activated Sludge Plastic Carrier Element

Technical Memorandum 4 – Effluent Disposal Options

Several effluent disposal options were considered in this TM, including land application via spray irrigation or subsurface drip irrigation, natural or constructed wetlands, aquifer recharge via deep well injection or high-rate infiltration, beneficial stream discharge, and surface water discharges outside the Rutherford County boundary.

Land application was evaluated as a viable effluent disposal option. Potential land application sites were identified from a soil study completed by MWSD in 2010. Parcels were selected based on suitable soil type, size of parcel, and proximity to other parcels. Potential land application sites were then grouped together to form eleven land application locations. The estimated capacity of each land application grouping was determined for both spray irrigation and subsurface drip disposal.

Drip Irrigation Effluent Disposal

There is a significant difference in the buffer requirements between drip disposal and spray irrigation, most likely due to the potential for spray to be carried offsite by wind or other influential factors. As such, spray irrigation yields approximately one-half to two-thirds the volumetric capacity of drip irrigation. However, spray irrigation is typically a lower capital cost alternative than drip disposal, so another option is to land apply using spray irrigation in the center of a site and then use subsurface drip disposal in the large spray buffer zones around the perimeter of the site. A spray/drip combination is essentially equivalent to the volumetric capacity of drip disposal irrigation. A disadvantage of the spray/drip combination is the hydraulic balance required between the two systems, potentially requiring two separate pumping systems. Additionally, drip disposal irrigation systems are maintenance intensive due to limited access and clogging issues. A spray/drip combination would also still require a wet weather storage reservoir for the spray irrigation portion of the system.

Spray Irrigation Effluent Disposal

In a Tennessee Water Reuse Inventory (2010) presented by the Center for the Management, Utilization, and Protection of Water Resources and TDEC at the Tennessee Association of Utility Districts Business conference, no Tennessee utilities were shown to use aquifer recharge, rapid infiltration, or wetlands for effluent disposal. Therefore, it is unlikely that these alternatives would be easily permitted as effluent disposal methods for MWSD. Using the J. Percy Priest Reservoir for a surface water discharge was previously determined to be an impractical option due to its use as a drinking water supply source. The Cumberland River surface water discharge option was found in previous studies to have high capital costs but remains a feasible effluent disposal option. In summary, land application appears to be the most viable effluent disposal option for MWSD. Land costs in the County are high, but there appears to be several feasible options for land application sites.

Technical Memorandum 5 – Centralized / Decentralized Treatment Alternatives

TM 5 contains a detailed evaluation of the myriad of wastewater capacity expansion alternatives available to MWSD. These expansion alternatives include several treatment and capacity combinations for a centralized expansion of the Sinking Creek WWTP. Additionally, there are multiple decentralized treatment combinations that may be considered either in lieu of, or in combination with, a centralized treatment plant expansion alternative.

Centralized and decentralized facilities are two treatment options that differ in size, collection system characteristics, treatment methods, and effluent disposal. Centralized treatment plants are more common in urban areas, and tend to be located near the point of effluent disposal, typically near a surface water discharge. The collection system that supports a centralized treatment plant is extensive. A decentralized treatment facility is typically located near the influent wastewater source and effluent disposal. The collection system is not as extensive for a decentralized facility, and the treatment capacity is typically capped by the effluent disposal volume. Decentralized facilities tend to be smaller in size, have smaller footprints than centralized facilities, and will frequently be constructed with advanced technologies.

There are two main categories of decentralized satellite treatment plants: scalping facilities and stand-alone facilities. A stand-alone satellite facility generally includes all of the same process functions as a centralized treatment facility and may have expansion opportunities built into the design. This type of facility is also located near the effluent disposal alternative, but different site considerations are required to determine the optimal location for a full-service facility. Solids from stand-alone satellite facilities can either be handled onsite or offsite. Conversely, scalping facilities typically divert a fixed quantity of influent flow from an existing collection system. The construction of scalping facilities may defer or eliminate collection systems improvements, will eliminate the need for equalization, and will route waste solids back to the collection system for treatment at the centralized facility, thus eliminating the cost of solids handling.

Centralized Treatment Alternatives

An expansion of the Sinking Creek WWTP would result in a lower target nitrogen and phosphorus concentration in order to maintain the fixed pollutant load thresholds to the West Fork Stones River. Currently, the permitted target effluent total nitrogen concentration is 9 mg/l. CBOD and ammonia could also be potentially affected. If the plant capacity is increased, then 1) the existing oxidation ditch process will have to reliability meet the new target concentration limits, 2) the existing oxidation ditch process will have to be modified to meet the new target concentration limits, or 3) a blend of the existing oxidation ditch process and an advanced nutrient removal sidestream facility on the Sinking Creek WWTP site would have to be constructed to meet the new target concentration limit.

The options for a centralized treatment plant expansion are numerous. Therefore, various combinations of the current extended aeration oxidation ditch technology with and without a parallel advanced nutrient removal sidestream facility were explored. An identical analysis was performed for total phosphorus removal; however, this pollutant can be removed via chemical precipitation and therefore is not the critical

factor in identifying expansion alternatives.

The Sinking Creek WWTP process was analyzed to preliminarily determine the ability of the plant to reliably achieve more stringent nutrient limits. Based on the current effluent flow and load data, it was determined that the existing oxidation ditch process may reliably treat to a target total nitrogen concentration of 7 mg/l if the plant were re-rated to a design flow of 20 mgd and a peak of 50 mgd. In all instances of influent flow exceeding 20 mgd, the plant successfully produced an effluent quality less than 7 mg/l of total nitrogen 100 percent of the time. The average effluent total nitrogen concentration at a flow greater than 20 mgd is 3.94 mg/l. The average effluent total phosphorus concentration at a flow greater than 20 mgd is 0.86 mg/l, illustrating that the process will meet the phosphorus threshold at a target concentration of 4 mg/l. In summary, the plant has consistently been able to produce an effluent quality that meets the permit criteria with the existing infrastructure.

In addition to effluent quality, each unit process at the Sinking Creek WWTP was evaluated for any process or hydraulic constraints. The preliminary treatment facility is hydraulically sized to pass a peak flow of 50 mgd. Do to age and wear, the screens are currently being replaced to increase the reliable capacity. The oxidation ditch process has sufficient aeration and treatment capacity to accommodate an increase in flow to 20 mgd. The calculated process rates for secondary clarification fall within acceptable design criteria for a plant re-rate to 20 mgd. The clarifiers are occasionally producing a cloudy and turbid effluent, which is problematic for downstream unit process operation (e.g., tertiary filtration and disinfection). Sampling recommendations have been made in an attempt to begin evaluating the problem. The tertiary filtration process rates are within the upper range of acceptable design criteria. The filter capacity is limiting at the current design flow of 16 mgd, particularly during wet weather events. It is recommended that additional filters be added to increase the process reliability at 16 mgd and accommodate a flow re-rate to 20 mgd. The limiting filter capacity will be particularly acute if the filters are ever used for denitrification capability. The disinfection and post aeration systems are also hydraulically sized to accommodate a new design flow of 20 mgd.

The centralized expansion alternatives at the Sinking Creek WWTP were narrowed to three alternatives that utilize the unit process rated capacity in even expansion increments. The first centralized expansion alternative is a hydraulic and process re-rating of Sinking Creek WWTP to 20 mgd without a physical expansion of the plant infrastructure. This alternative will reliably operate under the nutrient threshold without a compromise in treatment performance or reliability. A satellite facility will be required to accommodate additional flow in the service area and a request would have to be made to TDEC to consider a continuous 4 mgd increase to West Fork Stones River to offset the capital and operation costs associated with land application effluent disposal. The second alternative is the expansion of the Sinking Creek WWTP to 24 mgd with the construction of one additional oxidation ditch. Process modifications at the plant will be necessary, and a satellite facility may be required to accommodate additional flow in the service area. The third centralized expansion alternative is an expansion of the Sinking Creek WWTP to 32 mgd with the construction of two additional oxidation ditches. Significant process modifications would be necessary, and land application for effluent disposal would certainly be required.

Decentralized Treatment Alternatives

Decentralized Alternatives Analysis

A second alternative to a capacity expansion of the Sinking Creek WWTP is the development of a decentralized wastewater treatment system. The two primary considerations for decentralized treatment are 1) locate the treatment plant near the effluent discharge location, and 2) locate the decentralized treatment facility near the service area in which the wastewater is being generated to avoid and/or defer improvements to the existing collection system infrastructure.

Several factors were used to locate decentralized facilities in the urban growth boundary. First, the service area flow distribution maps were used to determine suitable locations for satellite facilities that could accommodate current and future flow requirements. The land application effluent disposal options evaluated in TM 4 (*Effluent Disposal Option*s) were used to determine potential satellite facility locations that would be in close proximity to potential land disposal sites. Additionally, City recommendations were considered for flow-shedding from two major interceptors that contribute significant influent flow (Sinking Creek and Stones River interceptors). These interceptors combine immediately upstream of the Sinking Creek WWTP. After the flow distribution analysis, the existing and proposed gravity sewer and force main routes were used to refine the locations of the potential satellite facility locations. The collection system infrastructure was also used to determine all sewer districts that would be served by each potential satellite facility. Twelve potential locations for decentralized satellite treatment facilities were identified.

Each satellite facility location has advantages and disadvantages. In many cases, the volumetric capacity of the land application effluent disposal locations would not accommodate the necessary satellite treatment capacity requirements. In most cases, more than three land application effluent disposal locations were necessary to accommodate the required satellite plant treatment capacity. The effluent disposal capacity of Jordan and Coleman Farms were also included in the evaluation in addition to the feasibility of a seasonal surface water discharge.

Recommended Alternatives

A matrix of eleven treatment capacity expansion and effluent disposal alternatives were recommended. The eleven recommendations were selected from the list of twelve satellite treatment facilities and the myriad of effluent disposal combinations in addition to several centralized treatment options. For decentralized treatment, suitable land application capacity combinations were paired with the most feasible satellite treatment facility site locations. The recommended alternatives only consider a combination of two or less satellite treatment facilities. From an operation and maintenance perspective, it seems unlikely that the construction of more than two additional satellite treatment facilities would be beneficial to the City.

The land application effluent disposal recommendations for the applicable alternatives are subsurface drip disposal, with the exception of spray irrigation on Jordan and Coleman Farms. Subsurface drip irrigation reduces the total amount of acreage needed for effluent disposal, so its use reduces the capital cost. Additionally, 30 day wet weather storage is required for spray irrigation but not required for drip irrigation, which significantly increases the capital cost. However, there is some question in regards to the reliability of subsurface drip disposal. This technology is maintenance intensive, but the O&M is extremely difficult to quantify for cost estimating purposes. Another option for the City is to use spray irrigation in the center of a site and then utilize subsurface drip disposal in the large spray buffer zones around the perimeter of the site. In terms of volumetric capacity, the spray/drip combination will be very similar to the volumetric capacity of drip disposal.

Technical Memorandum 6 – Collection System Evaluation

TM 6 provides an evaluation of the City's wastewater collection system relative to the aforementioned treatment, discharge, and effluent disposal alternatives. The analysis within TM 6 considers the extent of the existing collection system, projects proposed in the City of Murfreesboro Wastewater Facilities Plan (SSR, 2002 Revision), and projects planned or completed since the 201 Facilities Plan. GIS data, reported sanitary sewer overflow (SSO) locations, and the current and future needs based on the geographical distribution of projected wastewater flows were incorporated into this evaluation. Using this information, an evaluation of potential capital investment deferrals with the decentralized wastewater treatment options was completed.

Each of the eleven treatment capacity expansion and effluent disposal alternatives proposed in TM 5 were analyzed to determine their respective impacts on the planned or proposed collection system improvement projects, including the Southwest Regional Pump Station and Force Main. City staff reviewed the improvements proposed in the Facilities Plan and worked with Hazen and Sawyer to identify projects and related costs associated with the identified centralized and decentralized treatment and disposal alternatives. The three major projects identified as potentially affected by the treatment and disposal alternatives include the Southwest Regional Pump Station and Force Main, the VA Relief Sewer, and the Sinking Creek Relief Sewer Phase 2. Seven of the eleven proposed alternatives were determined to result in a potential elimination or reduction in size of the Southwest Regional Pump Station and Force Main, while only one alternative was determined to affect the proposed VA Relief Sewer and the second phase of the Sinking Creek Relief Sewer. For each alternative, the savings associated with the elimination of these projects were incorporated into the cost estimates prepared for TM 7. It was also concluded that many of the treatment and disposal alternatives could improve the condition of the SSO problem at manhole number 069A0030, but that hydraulic modeling was recommended to confirm the impact.

Technical Memorandum 7 – Capital Improvements Recommendations

This TM focuses on several of the more feasible recommended alternatives based on total construction and operation and maintenance (O&M) costs and many non-cost factors. Construction and O&M costs were estimated for treatment, piping infrastructure, effluent disposal, and collection system improvements

for each of the eleven recommended alternatives. The capital and O&M costs associated with each alternative were phased over a 20 year time period based on the capacity needs. The net present value (NPV) for the phased capital and O&M costs over a 20 year period was determined. The NPV was also converted to an equivalent annual cost (EAC) over the 20 year period. Refer to the attached table for a summary of the capital costs, O&M costs, EAC, and NPV for the eleven recommended alternatives.

A table of non-cost factors, including such factors as permitting ease, public acceptance, and long-term land use planning compliance, was developed to help further evaluate the eleven alternatives. A decision matrix was prepared that allows weighting of both cost and non-cost factors. Scores for each alternative were developed as a means to narrow the options. Based on this evaluation, the following range of projects was identified for further consideration:

Centralized Expansion Alternatives

- Alternative #1: Expand Sinking Creek WWTP by 11 mgd with a seasonal discharge to East Fork Stones River and spray/drip irrigation on Jordan/Coleman Farms and acquired property.
- Alternative #8: Expand Sinking Creek WWTP by 11 mgd with a continuous 4 mgd discharge to West Fork Stones River, a seasonal discharge to East Fork Stones River, and spray/drip irrigation on Jordan/Coleman Farms and acquired property.
- Alternative #9: Expand Sinking Creek WWTP by 11 mgd with a seasonal discharge to East Fork Stones River and a seasonal discharge to the Cumberland River.

Centralized and Decentralized Alternatives

- Alternative #5: Expand Sinking Creek WWTP by 8 mgd with a seasonal discharge to East Fork Stones River and spray/drip irrigation on Jordan/Coleman Farms and acquired property; and construct a 3 mgd satellite facility (S3) with spray/drip irrigation on acquired property.
- Alternative #6: Expand Sinking Creek WWTP by 8 mgd with spray/drip irrigation on Jordan/Coleman Farms and acquired property; and construct a 5 mgd satellite facility (S6) with spray/drip irrigation on acquired property.
- Alternative #11: Expand Sinking Creek WWTP by 4 mgd with a continuous 4 mgd discharge to West Fork Stones River; construct a 9 mgd pump station at site S1 then pump to satellite facility S5; collect an additional 1.5 mgd at S5; construct a satellite facility (S5) with spray/drip irrigation on acquired property.

Action Items

Several recommendations have been presented for long-term wastewater treatment and disposal for the City of Murfreesboro. Regardless of the alternative that is ultimately selected, several action items are recommended for completion, as follows:

Immediate Action Items:

- Apply for planning limits for a seasonal / continuous discharge of 4 mgd at West Fork Stones River (Outfall #001) and a seasonal / continuous discharge of 4 to 12 mgd in the East Fork Stones River (Outfall #002).
- Discuss with TDEC about commissioning a water quality model to evaluate the long-term feasibility of increased assimilative capacity in West Fork or East Fork Stones River.
- Initiate suggested sampling to identify secondary clarifier performance issues (monovalent and divalent cation ratio and dissolved oxygen profiling).

Near Term Action Items:

- Commission a re-rating study of the plant to 20 mgd. Initiate process sampling effort for biological process model construction and calibration.
- Consider additional tertiary filters to increase plant reliability at current design flow of 16 mgd.

Long-Term Action Items:

- Identify land application disposal sites and begin evaluation and appraisal process.

NOTE: Since Draft TM7 as presented does not incorporate the findings, results, and preferences discussed during the Project Team's March status meeting and April Board workshop, those results are also not reflected in this Executive Summary. Results and recommendations will be incorporated into the final report.

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Summary of Capital, Operation and Maintenance, Net Present Value, Equivalent Annual Cost, and Collection System Deferral Costs

Alternative	Capital Cost		Annual Operation and Maintenance Cost			20-Year Equivalent Annual Cost	20-Year Net Present Value	Collection System Improvement Deferral Cost
	Treatment [1]	Piping [2]	Pumping	Treatment	Land Application			
Alternative #1: Expand Sinking Creek by 11 mgd with seasonal discharge to East Fork Stones River, spray/drip irrigation Jordan/Coleman Farms and acquired property.	$124,350,000	$77,400,000	$200,000	$2,410,000	$700,000	$14,690,000	$199,600,000	$0
Alternative #8: Expand Sinking Creek by 11 mgd with continuous 4 mgd discharge to West Fork Stones River; seasonal discharge to East Fork Stones River; spray/drip irrigation on Jordan/Coleman Farms and acquired property.	$95,270,000	$78,630,000	$120,000	$2,410,000	$510,000	$12,360,000	$168,000,000	$0
Alternative #9: Expand Sinking Creek by 11 mgd with seasonal discharge to East Fork Stones River and seasonal discharge to Cumberland River.	$52,000,000	$111,710,000	$380,000	$2,410,000	$0	$11,370,000	$154,450,000	$0
Alternative #5: Expand Sinking Creek by 8 mgd with seasonal discharge to East Fork Stones River; spray/drip irrigation on Jordan/Coleman Farms and acquired property; and construct a 3 mgd satellite facility (S3) with spray/drip irrigation on acquired property.	$147,850,000	$82,710,000	$270,000	$3,120,000	$760,000	$17,910,000	$243,350,000	$0

City of MURFREESBORO TENNESSEE

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Summary of Capital, Operation and Maintenance, Net Present Value, Equivalent Annual Cost, and Collection System Deferral Costs

Alternative	Capital Cost		Annual Operation and Maintenance Cost			20-Year Equivalent Annual Cost	20-Year Net Present Value	Collection System Improvement Deferral Cost
	Treatment [1]	Piping [2]	Pumping	Treatment	Land Application			
Alternative #6: Expand Sinking Creek by 8 mgd with spray/drip irrigation on Jordan/Coleman Farms and acquired property; construct 5 mgd satellite facility (S6) with spray/drip irrigation on acquired property.	$157,760,000	$79,910,000	$240,000	$3,120,000	$870,000	$19,150,000	$260,270,000	$3,600,000
Alternative #7: Expand Sinking Creek by 4 mgd with continuous 4 mgd discharge to West Fork Stones River; construct a 4 mgd satellite facility (S4) with spray/drip irrigation on Jordan/Coleman Farms/acquired property; and construct a 5 mgd satellite facility (S6) with spray/drip irrigation on acquired property.	$152,680,000	$71,090,000	$390,000	$4,070,000	$500,000	$19,410,000	$263,730,000	$3,600,000
Alternative #10: Expand Sinking Creek by 4 mgd with continuous 4 mgd discharge to West Fork Stones River; construct 9 mgd satellite facility (S1) with spray/drip irrigation on Jordan/Coleman Farms and acquired property.	$147,080,000	$58,410,000	$130,000	$4,070,000	$490,000	$18,270,000	$248,260,000	$24,000,000
Alternative #11: Expand Sinking Creek by 4 mgd with continuous 4 mgd discharge to West Fork Stones River; construct 9 mgd pump station at site S1 then pump to satellite facility S5; collect an additional 1.5 mgd at S5; construct a satellite facility (S5) with spray/drip irrigation on acquired property	$186,110,000	$53,670,000	$210,000	$4,540,000	$520,000	$19,270,000	$261,870,000	$24,000,000

City of MURFREESBORO TENNESSEE

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Summary of Capital, Operation and Maintenance, Net Present Value, Equivalent Annual Cost, and Collection System Deferral Costs

Alternative	Capital Cost		Annual Operation and Maintenance Cost			20-Year Equivalent Annual Cost	20-Year Net Present Value	Collection System Improvement Deferral Cost
	Treatment [1]	Piping [2]	Pumping	Treatment	Land Application			
Alternative #2: Construct 12 mgd satellite facility (S11) with spray/drip irrigation on acquired property.	$192,620,000	$60,870,000	$280,000	$5,020,000	$600,000	$22,460,000	$305,230,000	$24,000,000
Alternative #3: Construct 9 mgd satellite facility (S1) with spray/drip irrigation on acquired property; and construct 3 mgd satellite facility (S10) with spray/drip irrigation on acquired property.	$209,260,000	$56,430,000	$270,000	$5,020,000	$800,000	$23,640,000	$321,300,000	$28,130,000
Alternative #4: Construct 9 mgd satellite facility (S1) with spray/drip irrigation on acquired property; and construct a 3 mgd satellite facility (S8) with spray/drip irrigation on acquired property.	$214,760,000	$60,850,000	$310,000	$5,020,000	$680,000	$23,640,000	$321,210,000	$24,000,000

[1] *Treatment includes wastewater capacity, land acquisition, land application, and wet weather storage reservoir costs.*
[2] *Piping includes infrastructure to route influent wastewater from the collection system to satellite facilities or treated effluent to land application effluent disposal.*

City of MURFREESBORO TENNESSEE