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Technical Memorandum 5 – Centralized / Decentralized Treatment Alternatives
Wastewater Treatment Capacity and Effluent Disposal Study
Murfreesboro Water and Sewer Department

The purpose of this technical memorandum (TM) is to provide a summary and analysis of the centralized and decentralized treatment alternatives for the expansion of wastewater treatment and disposal capacity in Murfreesboro. The treatment capacity expansion alternatives include an expansion of the Sinking Creek Wastewater Treatment Plant (WWTP) or the construction of decentralized, or satellite, treatment facilities. The effluent disposal alternatives consider a myriad of effluent disposal options, including land application via spray irrigation or subsurface drip irrigation, a seasonal surface water discharge to East Fork Stones, a modest increase in the surface water discharge to the West Fork Stones River, and a Cumberland River surface water discharge. Land application capacity combinations were paired with the satellite treatment facility site locations. A matrix of eleven potential treatment capacity expansion and effluent disposal alternatives was developed.

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1. Introduction

1.1 Objective of Analysis

The City of Murfreesboro is faced with several challenges for expanding and upgrading wastewater infrastructure. A growing population, an aging collection system, and environmental limitations on surface water discharges have complicated the planning process for the next capacity expansion. The objective of this Technical Memorandum (TM) is to provide a summary and analysis of the centralized and decentralized treatment alternatives for expansion of wastewater treatment and disposal capacity in Murfreesboro. This TM also includes a process analysis of the Sinking Creek Wastewater Treatment Plant (WWTP). Prior to this TM, baseline and projected wastewater flow was evaluated based on anticipated population growth and distribution (TM 1). The regulatory issues associated with effluent disposal in the watershed were discussed in TM 2. Treatment technologies were explored in TM 3, which was followed by an analysis of potential effluent disposal sites in the City's service area (TM 4).

1.2 Description of Centralized versus Decentralized Treatment

Centralized and decentralized facilities are two wastewater treatment options that differ in size, collection system characteristics, treatment methods, and effluent disposal. Centralized treatment plants are generally more common in urban areas. These facilities tend to be located near the point of effluent disposal, typically near a surface water discharge. The collection system that supports a centralized treatment system is extensive. Long pipe distances and frequent manholes and lift stations are common. Treatment is accomplished at a single facility, and the biosolids sidestream is typically treated and processed onsite prior to disposal. If treated effluent is being applied to a reclaimed water application, then long distribution lines are most often required to route water to the intended disposal site. Expansion of centralized treatment facilities requires careful consideration of construction sequencing to maintain an operational facility. Site, neighbor, or environmental constraints may also limit the options for expansion.

A decentralized treatment facility is typically located near the influent wastewater source and the effluent disposal option. The decentralized collection system is not as extensive, as the treatment capacity is usually capped by the effluent disposal volume. Decentralized systems are also associated with shorter and less-disruptive construction than centralized facilities. Due to the smaller size (generally less than 5 mgd), advanced treatment technologies are often economical and smaller in footprint. Implementing a reclaimed water application is a more practical approach for a decentralized facility due to the close proximity of effluent disposal.

There are two main categories of decentralized satellite treatment plants: scalping facilities and stand-alone facilities. Decentralized facilities are often referred to as stand-alone satellite facilities if a centralized facility treats the bulk of a service area's influent flow. A stand-alone satellite facility generally includes all of the same process functions as a centralized treatment facility. Stand-alone satellite facilities are typically larger than scalping facilities and have expansion opportunities built into the design. Stand-alone satellite facilities are 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.

A “scalping” facility is a term used to describe another type of satellite system. Satellite “scalping” facilities typically divert a fixed quantity of influent flow from an existing collection system. Scalping satellite plants are generally located at the most optimal location for effluent disposal. The advantages of scalping facilities include being able to treat influent flow at a constant treatment rate, deferring or eliminating collection systems improvements, eliminating the need for equalization, and routing waste solids back to the collection system for treatment at the centralized facility, thus eliminating the cost of solids handling. The disadvantage to scalping facilities is that they are generally smaller in size and are usually not designed for expansion. Additionally, the centralized treatment facility must be able to treat the increase in solids load through the treatment process and biosolids handling.

The disadvantage of either a scalping plant or a stand-alone satellite facility is a general increase in overall operation and maintenance costs to run additional treatment facilities. Operational costs include 1) optimizing and troubleshooting multiple wastewater treatment processes, 2) maintenance of different types of equipment, and 3) additional sampling, analytical, and reporting requirements. Operation and maintenance costs also to be considered include staffing, spare parts, inventory, administrative and compliance, and odor control, particularly in urbanized areas.

1.3 Review of Regulatory Issues

1.3.1 NPDES Permit Limits Summary

The Sinking Creek WWTP has a design capacity of 16 mgd that discharges to an outfall on the West Fork of the Stones River (Outfall #001) per National Pollutant Discharge Elimination System (NPDES) permit TN0022586. The plant has a total nitrogen limit of 9 mg/l (1,201 lb/day) and a monthly total phosphorus (TP) reporting requirement. The permit also contains stringent summer and winter ammonia-nitrogen requirements. The NPDES permit specifies seasonal concentration limits for ammonia and carbonaceous biochemical oxygen demand (CBOD), with the summer months being more restrictive than the winter months. Table 1-1 provides a summary of effluent limits contained in the NPDES permit.

1.3.2 Summary of Potential Effluent Surface Water Discharge Locations

The most recent draft version of the 2010 303(d) list was used to help gauge stream impairment status, the future possibility of more stringent nutrient effluent limits, and potential Total Maximum Daily Load (TMDL) development. The 303(d) list indicates that the stream segment of the West Fork Stones River at Outfall #001 is impaired due to nitrates and nitrites, total phosphorus, and siltation. In January 2010, the City submitted a letter to the Tennessee Department of Environment and Conservation (TDEC) that outlined seven different disposal strategies for the expansion of the Sinking Creek WWTP. Of the seven strategies, only three are potentially viable: 1) a seasonal expansion of the existing discharge into West Fork Stones River at Outfall #001, 2) new continuous discharge into East Fork Stones River at proposed

Outfall #002, and 3) new satellite WWTP with a seasonal discharge into East Fork Stones River at proposed Outfall #002. The proposed outfall location on the East Fork Stones River is an acceptable option for seasonal discharge. Refer to TM 2 – *Regulatory Analysis*, Figure 1-1 for an illustration of these existing and proposed discharge locations. TDEC will also consider the alternative of expanding the existing Sinking Creek WWTP discharge into the West Fork Stones River at the existing outfall during the winter months if pollutant loadings remain constant.

Table 1-1: Summary of NPDES Permit Limitations

Effluent Characteristics [1]	Monthly Average Conc. (mg/l)	Monthly Average Amount (lb/day)	Weekly Average Conc. (mg/l)	Weekly Average Amount (lb/day)	Daily Maximum Conc. (mg/l)	Daily Minimum Percent Removal
$CBOD_5$ (May 1 – Oct.31)	5	667	7.5	1,001	10	40
$CBOD_5$ (Nov. 1 – April 30)	10	1,334	15	2,002	20	40
Ammonia as N (May 1 – Oct. 31)	1	133	1.5	200	2	-
Ammonia as N (Nov. 1 – April 30)	2.2	294	3.3	440	4.4	-
Total Nitrogen [2]	9.0	1,201	-	-		-
Total Phosphorus [3]	Report	-	-	-	-	-
Suspended Solids	30	4,003	40	5,338	45	40
E. coli, cfu/100 ml [4]	126	-	-	-	941	-
Dissolved oxygen, instantaneous	-	-	-	-	-	6.0 mg/l
pH (Standard Units)	6 *(minimum)*	-	-	-	9	-

[1] *IC_{25} limitations are 99% and 74% effluent from May to October and from November to April, respectively. The IC_{25} is the Inhibition Concentration causing 25% reduction in survival and growth of test organisms.*
[2] *No separate test required for Total Nitrogen. Sum of TKN and nitrite plus nitrate is limited to 9.0 mg/l.*
[3] *Several amendments to the previous permit addressed the absence of a phosphorus limit in the permit. Instead, it is to be monitored as a "Report" only parameter. The stream is effluent dominated. Limiting the nitrogen versus phosphorus continues to keep the N to P ratio less than 10:1, and thus postpones the engineering of any phosphorus removal process until the TMDL establishes a waste load allocation on which to base a design.*
[4] *Recently, EPA proposed a new method in 40 CFR, Part 136 for measuring E. coli in effluent matrices, Method #1603.*

1.4 Nutrient Load Thresholds in West Fork Stones River

TDEC has stated that pollutant load thresholds will be applied to the West Fork Stones River due to this receiving stream's water quality impairment status. The current total nitrogen permitted load is 1,201 lb/day, which equals 9 mg/l total nitrogen at 16 mgd. A load of 1,201 lb/day equals a yearly total nitrogen load threshold of 438,350 lb/yr. The current NPDES permit specifies only a reporting requirement for total phosphorus. However, currently the Sinking Creek WWTP discharges 4 mg/l of total phosphorus approximately 95 percent of the time. The associated total phosphorus load threshold at a permitted design flow of 16 mgd and a concentration of 4 mg/l total phosphorus equals 534 lb/day, or

194,822 lb/year. 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.

The NPDES permit contains other oxygen-consuming limits for ammonia and CBOD. These limits are permitted on a seasonal basis. Currently, the CBOD and ammonia limits are extremely stringent in the warmer months at 5 mg/l and 1 mg/l, respectively. A reduction in these concentration limits will reduce the reliability of the existing treatment process at the Sinking Creek WWTP. It is possible that TDEC would consider a reduction in the pollutant load for ammonia and CBOD as a result of a plant expansion, but it could be argued that the contribution of these pollutants is insignificant compared to the total nutrient load. Ammonia and CBOD should not be considered contributory to the overall impairment status of the receiving stream.

Tables 1-2 and 1-3 provide a summary of the pollutant load mass balance that would be required to maintain the total nitrogen and total phosphorus at the fixed thresholds, respectively. 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 limits. Both tables contain colored values that denote the nutrient loads that are less than or equal to the fixed nutrient thresholds.

The data in Table 1-2 indicates a plant capacity expansion may require that the existing oxidation ditch be modified to an advanced nutrient removal facility in order to meet the total nitrogen threshold. The plant could be expanded up to 24 mgd if the existing facility was retrofitted to meet a 4 mg/l total nitrogen target. Conversely, the existing oxidation ditch may be operated using the existing process configuration, but a parallel advanced nutrient removal sidestream facility would be required such that the blended flow would achieve the total nitrogen threshold.

The data in Table 1-3 indicated that the existing oxidation ditch process configuration could meet the total phosphorus limit if chemical were added to precipitate phosphorus. Or, several combinations of the existing process and an advanced nutrient removal sidestream facility could be used to meet the total phosphorus threshold. If chemical addition in the existing process were chosen as the optimal alternative, the secondary clarifier and biosolids handling facility equipment capacities would need to be verified. Chemical addition can add up to 30 percent more solids in the activated sludge process. The percentage varies among different facilities due to the influent matrix and the required target effluent phosphorus concentration.

Table 1-2: Oxidation Ditch and Parallel Sidestream Facility Flow and Load Combinations Required to Maintain Total Nitrogen Threshold of 1,201 lb/day

Oxidation Ditch Flow, mgd	BNR Sidestream[1]	Oxidation Ditch 9 mg/l TN	BNR Sidestream 4 mg/l TN	Oxidation Ditch 7 mg/l TN	BNR Sidestream 4 mg/l TN	Oxidation Ditch[2] 4 mg/l TN	BNR Sidestream 4 mg/l TN	Oxidation Ditch 7 mg/l TN	BNR Sidestream 3 mg/l TN	Oxidation Ditch[2] 6 mg/l TN	BNR Sidestream 2 mg/l TN	Oxidation Ditch[2] 4 mg/l TN	BNR Sidestream 3 mg/l TN
16	0	1,201		934		534		934		801		534	
16	2	1,118		1,001		600		984		834		584	
16	4	1,184		1,184		667		1,034		867		634	
16	8	1,468		1,201		801		1,134		934		734	
20	0	1,501		1,168		667		1,168		1,001		667	
20	4	1,635		1,301		801		1,268		1,068		767	
20	8	1,768		1,434		934		1,368		1,134		934	
24	0	1,801		1,401		801		1,401		1,201		801	
24	4	1,935		1,535		934		1,501		1,268		967	
24	8	2,068		1,668		1,068		1,601		1,334		1,001	
24	12	2,202		1,801		1,201		1,701		1,401		1,101	
24	16	2,335		1,935		1,334		1,801		1,468		1,201	

[1] *Biological nutrient removal sidestream facility with advanced biological nutrient removal.*
[2] *Oxidation ditch will require modifications or a retrofit to meet a target effluent nitrogen concentration of 4 or 6 mg/l.*
[3] *Highlighted cells denote a mass load less than or equal to the total nitrogen threshold of 1,201 lb/day (or 438,350 lb/yr).*

Table 1-3: Oxidation Ditch and Parallel Sidestream Facility Flow and Load Combinations Required to Maintain Total Phosphorus Threshold of 534 lb/day

Oxidation Ditch Flow, mgd	BNR Sidestream [1]	Oxidation Ditch 4 mg/l TP	BNR Sidestream 1 mg/l TP	Oxidation Ditch 4 mg/l TP	BNR Sidestream 0.2 mg/l TP	Oxidation Ditch 2 mg/l TP	BNR Sidestream 1 mg/l TP	Oxidation Ditch 2 mg/l TP	BNR Sidestream 0.2 mg/l TP	Oxidation Ditch 1 mg/l TP	BNR Sidestream 1 mg/l TP	Oxidation Ditch 1 mg/l TP	BNR Sidestream 0.2 mg/l TP
16	0	534		534		267		267		133		133	
16	2	550		537		284		270		150		137	
16	4	567		540		300		274		167		140	
16	8	600		547		367		280		200		147	
20	0	667		667		334		334		167		167	
20	4	701		674		367		340		200		173	
20	8	734		681		400		347		234		180	
24	0	801		801		400		400		200		200	
24	4	834		807		434		407		234		207	
24	8	867		814		467		414		267		214	
24	12	901		821		500		420		300		220	
24	16	934		827		534		427		334		227	

[1] *Biological nutrient removal sidestream facility with advanced biological nutrient removal.*
[2] *Highlighted cells denote a mass load less than or equal to the total phosphorus threshold of 534 lb/day (or 194,822 lb/yr).*

2. Sinking Creek WWTP Influent and Effluent Characterization

The Sinking Creek WWTP influent and effluent was analyzed to determine the ability of the plant to reliably achieve more stringent nutrient limits. Plant flow and loads were analyzed with respect to influent design parameters and historic trends. The influent composite sampler is located in the influent force main between the main influent pump station and preliminary treatment. Samples are taken prior to any treatment, including screening. The influent samples do include plant sidestream flow. Solids handling filtrate, building drains, and preliminary treatment sidestreams are routed to the main influent pump station. According to plant staff, the volume and rate of the sidestream is not known.

The influent design values for the Sinking Creek WWTP are provided in Table 3-1. Typical carbonaceous biochemical oxygen demand (CBOD) values for untreated domestic wastewater range from 110 mg/l to 350 mg/l. The plant's design value of 200 mg/l lies within the range of a typical influent wastewater concentration. Additionally, typical concentrations of ammonia and total suspended solids (TSS) in domestic wastewater range from 12 mg/l to 45 mg/l and 120 mg/l to 400 mg/l, respectively. Similar to CBOD, the design values for ammonia and TSS are in the medium strength range. The design values shown in Table 2-1 were based on plant data from the mid to late 1990s.

Table 2-1: Influent Design Parameters for the Sinking Creek WWTP

$CBOD_5$ [1]		Ammonia (NH_3) [1]		Total Suspended Solids [1]	
mg/l	lb/day	mg/l	lb/day	mg/l	lb/day
200	26,700	28	3,740	200	26,700

[1] *From Preliminary Engineering Report, Sinking Creek Wastewater Treatment Plant Phase 4c Expansion (Smith Seckman Reid, Inc., May 2008).*

The analysis for the Sinking Creek WWTP includes a detailed evaluation of plant monitoring report data from January 1, 2007 to June 30, 2010. The annual average, maximum and minimum month, and the rolling 30-day and 7-day averages were calculated for flow, CBOD, TSS, ammonia nitrogen, dissolved oxygen (DO), and influent temperature. Fiscal year data were used in lieu of calendar year data to take advantage of the most recent plant data. Table 2-2 summarizes the influent flow and concentrations for each of the three fiscal years, and Table 2-3 provides the corresponding load and peaking factors relative to the annual average. A detailed summary of the data is provided in Attachment A. The graphical analysis is provided in Attachment B, and should be used for reference herein.

A statistical analysis was performed on all plant data as an evaluation tool for treatment reliability. It is important to note that the statistical analyses presented in this report are based on individual daily occurrences. NPDES permit limits are based on monthly averages except for dissolved oxygen, which is an instantaneous daily minimum. Therefore, these analyses do not indicate that the Sinking Creek WWTP is in violation of its NPDES permit. Rather, the permit limit monthly averages are used as a benchmark value for the statistical evaluation.

2.1 Influent and Effluent Flow

According to historic influent flow data from 1988 to 2007 (*Preliminary Engineering Report*, SSR, 2008), influent flow to the plant has gradually been increasing over time, most markedly in 2001. In 2002, the annual average influent flow to the plant was 10.8 mgd. In 2007, the annual average influent flow was 13.1 mgd, demonstrating a growth of approximately 0.5 mgd per year. In 2010, the annual average influent flow was 16.5 mgd.

The City sends a large portion of the plant effluent to the repurified water system, particularly in the warmer months. The following points are observations of the Sinking Creek WWTP effluent flow data:

- The average daily effluent flow discharged to West Fork Stones River is approximately 12.7 mgd and has ranged from 3.8 to 33.4 mgd.
- From 2007 to 2010, the City sent out an average of 2.45 mgd to the repurified water system.
- Repurified flow varies seasonally and may be as low 0.23 mgd (1.6 percent of influent) in the winter, or as high as 8.28 mgd (61.8 percent of influent) in the summer.
- An effluent flow of 12 mgd is discharged at least 50 percent of the time.
- An effluent flow of 16 mgd is discharged at least 80 percent of the time.
- An effluent flow of 20 mgd is discharged at least 90 percent of the time.

The City has documented infiltration and inflow (I/I) in the collection system during wet weather events. Peak influent flow has increased in frequency and volume over the last three years. In fiscal year 2008, the maximum instantaneous flow into the plant was approximately 36 mgd. In fiscal year 2010, there were seven occurrences where the instantaneous maximum flow reached 50 mgd. In the last three years, the staff was forced to bypass treatment only once. This bypass was due to an EF4-rated tornado that struck Murfreesboro at 12:45 pm on April 10, 2009. The bypass occurred on April 11 and 12, 2009. The tornado destroyed 117 homes, caused 298 homes to have major damage, and left 175 homes with minor damage. Table 2-4 summarizes the maximum instantaneous flow events, precipitation, and average concentrations of $CBOD_5$, ammonia, TSS, mixed liquor suspended solids (MLSS), and sludge volume index (SVI) for each of the maximum instantaneous flow events.

Table 2-2: Influent Flow Parameter Concentrations for Sinking Creek WWTP

Parameter	Fiscal Year [1]	Flow (mgd)	Flow Peaking Factor [2]	$CBOD_5$ (mg/l)	TSS (mg/l)	NH_3 (mg/l)	Dissolved Oxygen (mg/l)	Temperature (°C)
Minimum Month	2008	11.4	0.81	129	204	12.0	4.0	15.5
	2009	10.9	0.72	198	286	8.9	3.9	14.9
	2010	12.6	0.76	123	142	8.9	4.2	13.7
Fiscal Year Average	2008	14.1	1.0	175	250	17.6	5.1	20.5
	2009	15.1	1.0	255	343	15.5	5.3	19.7
	2010	16.5	1.0	194	229	14.5	5.4	19.2
Rolling 30 Day Average	2008	19.3	1.37	227	297	26.0	6.4	26.5
	2009	22.6	1.50	315	421	23.4	7.0	25.5
	2010	26.0	1.58	281	396	24.3	6.9	24.2
Rolling 7 Day Average	2008	24.7	1.75	254	315	28.6	6.9	26.6
	2009	30.4	2.01	331	460	24.7	7.2	25.8
	2010	30.3	1.84	299	422	25.9	7.1	24.6
Maximum Month	2008	18.2	1.29	219	292	23.8	6.0	26.1
	2009	22.0	1.46	310	406	22.4	6.9	25.4
	2010	21.9	1.33	278	392	21.9	6.9	23.9

[1] *July 2007 to June 2008, July 2008 to June 2009, and July 2009 to June 2010.*
[2] *Peaking factor is calculated for flow relative to the fiscal year average.*

Table 2-3: Influent CBOD, Suspended Solids, and Ammonia Loads for Sinking Creek WWTP

Parameter	Fiscal Year	$CBOD_5$ (lb/d)	Peaking Factor [2]	TSS (lb/d)	Peaking Factor	NH_3 (lb/d)	Peaking Factor
Minimum Month	2008	14,112	0.71	22,963	0.80	1,635	0.84
	2009	18,716	0.62	27,191	0.66	1,470	0.84
	2010	20,437	0.82	23,440	0.80	1,547	0.84
Fiscal Year Average	2008	20,008	1.00	28,593	1.00	1,946	1.00
	2009	30,401	1.00	41,335	1.00	1,751	1.00
	2010	25,065	1.00	29,418	1.00	1,834	1.00
Rolling 30 Day Average	2008	25,992	1.30	34,589	1.21	2,552	1.31
	2009	39,324	1.29	58,708	1.42	2,164	1.24
	2010	31,164	1.24	43,832	1.49	2,381	1.30
Rolling 7 Day Average	2008	27,932	1.40	42,498	1.49	2,810	1.44
	2009	45,271	1.49	69,092	1.67	2,388	1.36
	2010	33,176	1.32	47,063	1.60	2,551	1.39
Maximum Month	2008	25,203	1.26	33,561	1.17	2,284	1.17
	2009	37,298	1.23	56,626	1.37	2,124	1.21
	2010	30,579	1.22	43,376	1.47	2,289	1.25

[1] *July 2007 to June 2008, July 2008 to June 2009, and July 2009 to June 2010.*
[2] *Peaking factors are calculated relative to the fiscal year average.*

Table 2-4: Summary of Peak Flow Occurrences with Corresponding $CBOD_5$, TSS, and MLSS Concentrations in Fiscal Year 2010

Date	Maximum Instantaneous Flow (mgd)	Precip-itation (in)	Influent $CBOD_5$ (lb/d)	Influent Ammonia Nitrogen (lb/d)	Influent TSS (lb/d)	MLSS in Train #1 (mg/l)	MLSS in Train #2 (mg/l)	SVI in Train #1 (mg/l)	SVI in Train #2 (mg/l)	Number of Occurrences of Bypass Treatment (Total Hours)
3/13/2009	22.0	0.6	28,863	1,415	38,670	3,917	3,943	140	139	0
3/14/2009	34.9	0.8	39,668	-	46,420	3,028	3,041	165	156	0
3/15/2009	29.0	0.5	17,920	-	10,888	2,485	2,565	121	136	0
3/25/2009	21.2	0.4	27,188	1,794	44,588	3,756	4,092	133	122	0
3/26/2009	40.1	1.5	134,770	1,853	260,983	3,618	3,328	124	135	0
3/27/2009	36.5	0	14,449	1,077	13,302	2,004	2,512	137	139	0
4/1/2009	50.0	0.1	30,734	1,162	52,331	3,415	3,443	124	131	0
4/10/2009	26.5	0.3	Tornado [1]	1,441	-	4164	3,833	132	143	1 (11.15)
4/11/2009	25.4	0.4	20,643	-	21,834	-	-	-	-	1 (16.35)
4/21/2009	22.0	0.1	44,602	1,433	63,399	3,365	13,980	125	30	0
5/21/2009	19.5	0	36,902	1,032	64,766	9,667	9,460	47	53	0
4/24/2010	49.9	0.1	23,854	-	26,691	3,660	2,603	198	221	0
4/25/2010	19.5	2.2	19,066	-	17,527	3,120	2,289	196	186	0
5/2/2010	36.4	6.7	20,296	-	21,337	2,109	1,839	190	190	0
5/3/2010	37.0	5.1	41,326	354	40,058	1,757	1,536	205	195	0
5/10/2010	49.9	0	24,907	1,761	30,549	2,196	2,131	159	164	0
5/11/2010	36.9	0.1	36,402	1,379	47,558	2,138	2,184	164	172	0
5/12/2010	47.1	0	15,699	1,479	15,095	2,208	1,905	159	157	0
5/13/2010	50.0	0	8,256	1,431	4,403	2,502	1,770	156	155	0
5/14/2010	50.0	0	16,574	1,782	25,348	2,526	2,327	158	172	0
5/21/2010	49.9	0.5	13,335	1,245	16,681	2,505	2,223	196	214	0
Average values from Jan 2009 to June 2010	21.4	0.17	22,468	1,360	28,384	3,259	3,051	130	133	-

[1] *The CBOD test was set up 4/5/2009 and due off 4/10/2009. These samples were not taken off before the tornado hit and all power was lost.*

2.2 Carbonaceous Biochemical Oxygen Demand

The influent CBOD has exhibited an erratic trend over the last 15 years. In 1995, the average influent CBOD concentration was slightly less than 200 mg/l (the plant design value). In 1999, the influent CBOD concentration increased to 289 mg/l. This increase was thought to be primarily due to water conservation. In 2010, the influent CBOD concentration decreased to 195 mg/l. In the last three years, the minimum month CBOD has ranged from 123 to 198 mg/l and the maximum month $CBOD_5$ has ranged from 219 to 310 mg/l. The annual average CBOD concentration in fiscal year 2010 was 194 mg/l (25,069 lbs/day), which is close to the influent design value of 200 mg/l CBOD. Instantaneous maximum CBOD concentrations have exceeded 400 mg/l.

The influent annual average CBOD load has ranged from 20,000 to 30,300 lb/day between 2007 and 2010. The minimum month CBOD ranges from 14,000 lb/day to 20,000 lb/day. Periods of high influent CBOD correspond with periods of high influent flow. On March 26, 2009 the plant faced extremely high CBOD loading of 134,770 lbs/day concurrent with 261,000 lb/d of TSS. Murfreesboro received 1.5 inches of rain that day and had a maximum instantaneous flow of 40.1 mgd. More typical instantaneous maximum CBOD loads range from 40,000 to 50,000 lb/day.

Daily effluent CBOD concentrations meet the monthly average permit limit of 5 mg/l in the summer 87.7 percent of the time and the monthly average winter limit of 10 mg/l approximately 99.7 percent of the time. The effluent CBOD concentration in the data set is 3.3 mg/l, with a range between 1.0 to 13.0 mg/l. Effluent $CBOD_5$ concentrations were particularly high between January 2007 and July of 2008 with a monthly average of 4.0 mg/l. The $CBOD_5$ effluent concentration has decreased since July 2008 with an average 2.67 mg/l from August 2008 to June 2010. Percent removal efficiencies range from 87.5 to 99.7 percent with an average of 98.1 percent removal. In general, the current biological treatment infrastructure has been highly effective in removing CBOD.

2.3 Total Suspended Solids

The influent TSS concentration has exceeded the design value of 200 mg/l since 1997 and has continued to remain elevated. Influent TSS averaged 229 mg/l in fiscal year 2010. There are several instances in the data set in which monthly maximum TSS concentrations have been as high as 1,400 mg/l. The minimum month and maximum month for influent TSS have ranged from 142 to 286 mg/l and 292 to 406 mg/l, respectively.

Annual average influent TSS loads have ranged from 28,600 to 41,300 lb/day. The minimum month TSS is approximately 23,000 lb/day. The maximum average month ranges from 33,600 lb/day to 56,600 lb/day. Instantaneous maximum TSS loads have exceeded 60,000 lb/day.

Effluent TSS concentrations range from 0.1 to 13.4 mg/l with an average of 0.8 mg/l. Removal efficiencies average 99.7 percent and range from 94.4 to 100 percent. Daily effluent TSS concentrations have not exceeded the monthly average permit limit of 30 mg/l.

2.4 Ammonia

The annual average influent ammonia has remained consistently below the plant design value of 28 mg/l. Historical annual average influent ammonia concentrations have ranged from 15 to 18 mg/l. In the last three years, the average influent ammonia concentration has ranged from 14.5 to 17.6 mg/l. The minimum month and maximum month for influent ammonia ranged from 8.9 to 12 mg/l and 21.9 to 23.8 mg/l, respectively. These average ammonia values are lower than in typical raw wastewater influent, and may be due to dilution via I/I contribution or flow contribution from the solids handling facility.

Effluent ammonia concentrations met the monthly average summer permit limit of 1.0 mg/l occurring 99.7 percent of the time and the monthly average winter permit limit of 2.2 mg/l occurring 97.9 percent of the time, indicating effective nitrification in the oxidation ditches.

2.5 Dissolved Oxygen and Influent Temperature

Influent dissolved oxygen exhibits a cyclical pattern based on season. In the winter months, the dissolved oxygen concentration ranges between 6 and 8 mg/l. In the summer months, the dissolved oxygen concentration ranges between 4 and 5 mg/l. The Sinking Creek WWTP influent dissolved oxygen concentration is two to three times higher than the dissolved oxygen concentration in influent comprised of primarily domestic waste.

Effluent dissolved oxygen ranges from 1.0 to 14.4 mg/l with an average of 9.9 mg/l. The plant is achieving effluent dissolved oxygen concentrations well in excess of the 6 mg/l permit minimum. Daily effluent dissolved oxygen concentrations met the daily instantaneous minimum 100 percent of the time in the summer and 99.85 percent of the time in the winter.

Influent temperatures ranged from 12.0 to 27.8°C within the data set. Fiscal year 2010 was the coldest year with a monthly average of 13.7°C in February 2010. Winter monthly averages typically range from 14 to 17°C. In the summer months, monthly averages for influent temperatures can be as high as 26.1°C (August 2007), but typically range from 19.0 to 25.0°C. Depending on region, the mean annual temperature of wastewater in the United States may vary from 3 to 27°C.

2.6 Activated Sludge Process Variables

The average MLSS concentration of the two oxidation ditch trains is approximately 3,500 mg/l at design flow, with a typical range between 2,000 and 4,000 mg/l. During high flow events, plant staff turns down the return activated sludge pumps to 50 percent of design flow and the MLSS concentration is reduced to 2,000 to 2,500 mg/l. The MLSS concentrations tend to be slightly higher in carrousel basin 1 than in carrousel basin 2, which may be due to a slightly uneven flow-split upstream of the aeration basins.

The food to mass ratio (F/M) was calculated for the Sinking Creek WWTP to assess the operating point of the facility. Mixed liquor volatile suspended solids (MLVSS) data were unavailable, so it was assumed that

the MLVSS was 75 percent of the MLSS concentration. The F/M ratio averaged 0.09 lb $CBOD_5$/lb MLVSS·d. The minimum and maximum F/M ratios were calculated to be 0.02 and 0.46 lb $CBOD_5$/lb MLVSS·d, respectively. The high F/M ratios in March 2009 and May 2010 can be explained by the high $CBOD_5$ load that occurred on those days. Per Table 2-4, elevated MLSS concentrations generally correspond to high $CBOD_5$ and TSS loadings and higher than normal SVI.

The sludge volume index (SVI) is a measurement used to quantify the settling characteristics of sludge. Specifically, it is the volume of 1 gram of sludge produced after 30 minutes of settling. The lower the SVI value, the better the sludge settling characteristics. Two major issues in wastewater solid-liquid separation are pinpoint floc and filamentous bulking. Pinpoint floc is associated with low SVI values in which the activated sludge settles rapidly but may produce turbid effluents. Filamentous bulking is associated with high SVI values and is caused by an overabundance of filamentous organisms. These organisms decrease sludge settleability but produce effluent with low-turbidity because the filaments filter out the small particles as the sludge settles. Ideal sludge is that which has a low SVI, and a good balance between filamentous organisms and floc-forming organisms. Typically, SVI values below 80 are considered to be an excellent settling sludge. SVI values between 80 and 150 indicate moderate settling sludge, and SVI values greater than 150 are associated with filamentous growth in the sludge floc. An SVI of 150 is considered the dividing line between bulking and non-bulking sludge.

Historic SVI values at the Sinking Creek WWTP have generally been less than 100. However, in the last three years the plant SVI averaged 120, illustrating a trend in declining sludge settling quality. In June 2010, plant SVI ranged from 180 to 200. Plant staff has indicated that the sludge has an occasional cloudy or turbid appearance.

2.7 Nitrogen and Phosphorus

A historic record is not available for influent total nitrogen and phosphorus. However, on February 14, 2011, plant staff collected two influent samples to analyze for total Kjeldahl nitrogen (TKN) and total phosphorus. The first influent sample included the contribution from the rotary press filtrate sidestream flow. The second influent sample was taken without the rotary presses operating, and therefore can be considered a true characterization of the domestic wastewater influent matrix. The influent TKN concentrations were 53 and 29 mg/l with and without the rotary press sidestream flow, respectively. Influent total phosphorus concentrations were 8.6 and 3.4 mg/l with and without the rotary press sidestream flow, respectively. The 29 mg/l TKN and 3.4 mg/l total phosphorus values are of a lower strength than typical domestic wastewater. However, the rotary press sidestream contributes significantly to the influent nitrogen and phosphorus load, as indicated by the 53 mg/l TKN and 8.6 mg/l total phosphorus concentrations.

Effluent TKN does not appear to exhibit refractory nitrogen. Effluent TKN has ranged from 1 to 2 mg/l over the last three years, which are typical values for effluent TKN from domestic treatment facilities. If refractory nitrogen were present, TKN values would consistently be greater than 2 or 3 mg/l. Effluent nitrate concentrations range from 3 to 5 mg/l. Total effluent nitrogen concentrations (organic nitrogen,

ammonia nitrogen, and nitrite / nitrate nitrogen) range from 5 to 7 mg/l. The plant total nitrogen effluent permit limit is 9 mg/l. This permit limit was exceeded once during the last three years, in October 2009. Specifically, daily nitrogen concentrations have met the plants monthly average total nitrogen limit 97.5 percent of the time in the summer and 100 percent of the time in the winter.

Although the current NPDES permit does not have a phosphorus limit, the plant is currently discharging less than or equal to 3 mg/l total phosphorus 69 percent of the time and less than or equal to 4 mg/l total phosphorus 92 percent of the time on a daily basis. The average effluent phosphorus concentration is 2.4 mg/l with a minimum and maximum of 0.1 and 5.8 mg/l, respectively. The plant is not specifically designed for phosphorus removal; however, it appears that luxury phosphorus release and uptake is occurring in the oxidation ditches.

2.8 Summary of Statistical Analysis

Table 2-5 summarizes the statistical analysis of effluent quality at the Sinking Creek WWTP between January 1, 2007 and June 30, 2010. Generally, the Sinking Creek WWTP is consistently meeting monthly average permit limits even at flows greater than the design value of 16 mgd. The permit limit that is exceeded the most is the summer $CBOD_5$ limit of 5 mg/l, which is exceeded 12.3 percent of the time.

2.9 Process and Hydraulic Re-Rating for Sinking Creek WWTP

The analysis of the aforementioned data suggests that there is potential for the Sinking Creek WWTP to be re-rated from 16 to 20 mgd using the existing plant infrastructure. Influent flow to the Sinking Creek WWTP has exceeded the design flow of 16 mgd approximately 28 percent of the time. The plant successfully treats flows of at least 20 mgd 89.6 percent of the time on a year-round basis. The plant has consistently been able to produce effluent that meets the permit criteria with the existing infrastructure.

The data in Table 1-2 indicate that the plant can meet the permitted total nitrogen threshold of 1,201 lb/day if a target concentration limit of 7 mg/l is met at 20 mgd. Per Table 2-5, a total nitrogen concentration of less than or equal to 7.0 mg/l is consistently achieved 94 percent of the time. Furthermore, 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. Figure 2-1 illustrates the flow instances greater than 20 mgd and the corresponding effluent total nitrogen quality. The average effluent total nitrogen concentration at a flow greater than 20 mgd is 3.94 mg/l.

Figure 2-2 illustrates the flow instances greater than 20 mgd and the corresponding effluent total phosphorus quality. The average effluent total phosphorus concentration at a flow greater than 20 mgd is 0.86 mg/l, illustrating that the Sinking Creek WWTP process will meet a phosphorus threshold of 534 lb/day at a target concentration of 4 mg/l.

Table 2-5: Statistical Analysis of Sinking Creek WWTP Effluent Quality

Parameter	Term	Monthly Average Permit Limit Benchmark	Percent Less Than or Equal to Monthly Average Permit Limit (or Concentration Target) as a Benchmark [1]
Influent Flow	Year-round	16 mgd (effluent limit)	72.3%
	Summer		83.9%
	Winter		61.6%
	Year-round	20 mgd [2]	89.6%
	Summer		94.5%
	Winter		85.2%
Total Nitrogen	Year-round	9.0 mg/l (effluent limit)	98.8%
	Summer		97.5%
	Winter		100.0%
	Year-round	7.0 mg/l [2]	94.0%
	Year-round	5.0 mg/l [2]	75.0%
Total Phosphorus [3]	Year-round	4.0 mg/l	91.7%
	Summer		87.5%
	Winter		95.5%
	Year-round	3.0 mg/l	69.0%
	Summer		57.5%
	Winter		79.6%
Ammonia	Year-round	1.0 mg/l	98.0%
	Summer	1.0 mg/l	99.7%
	Winter	2.2 mg/l	97.9%
CBOD	Year-round	5 mg/l	85.3%
	Summer	5 mg/l	87.7%
	Winter	10 mg/l	99.7%
Total Suspended Solids	Year-round	30 mg/l	100.0%
	Summer		100.0%
	Winter		100.0%
E. coli	Year-round	126 CFU / 100 ml	98.8%
	Summer		98.9%
	Winter		98.6%
Dissolved Oxygen [4]	Year-round	6.0 mg/l	99.9%
	Summer		100.0%
	Winter		99.9%

Table 2-5: Statistical Analysis of Sinking Creek WWTP Effluent Quality

Parameter	Term	Monthly Average Permit Limit Benchmark	Percent Less Than or Equal to Monthly Average Permit Limit (or Concentration Target) as a Benchmark [1]

[1] This analysis does not infer that the Sinking Creek WWTP is not meeting its permit limits. The monthly average permit limit is used as a benchmark for the statistical evaluation. The plant has consistently produced an effluent quality that meets the NPDES permit criteria.
[2] Value based on effluent discharge data.
[3] Monitoring requirement for phosphorus. Concentration data is based on actual effluent discharge.
[4] Instantaneous daily minimum limit.

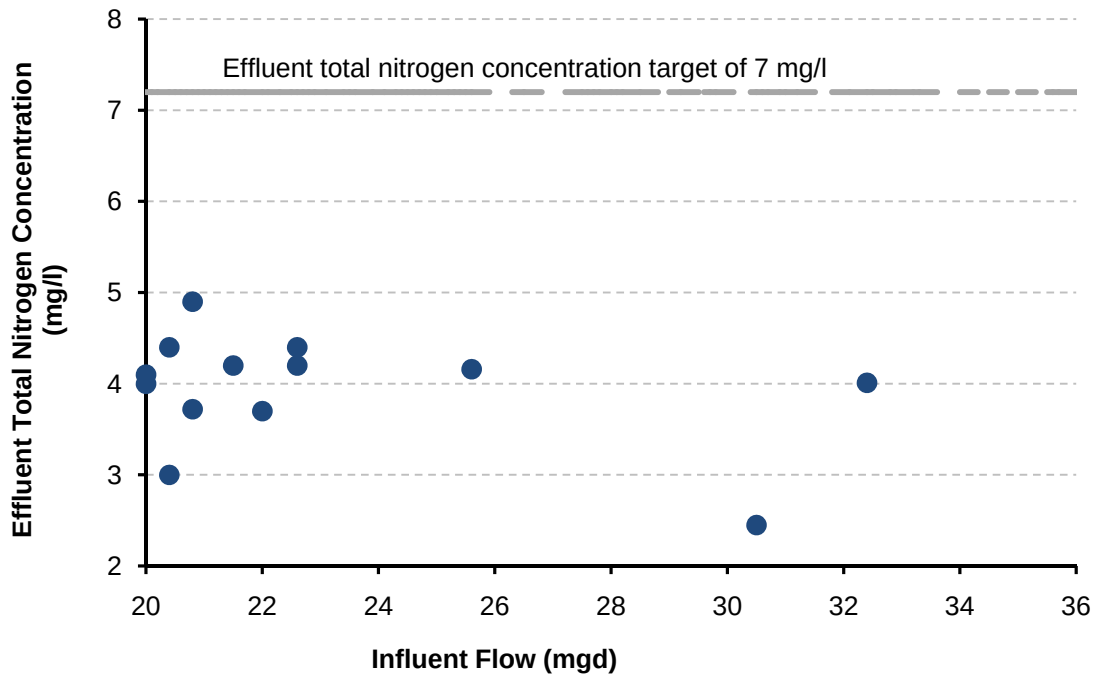


Figure 2-1: Effluent Total Nitrogen Concentration at Flow Greater Than or Equal to 20 mgd

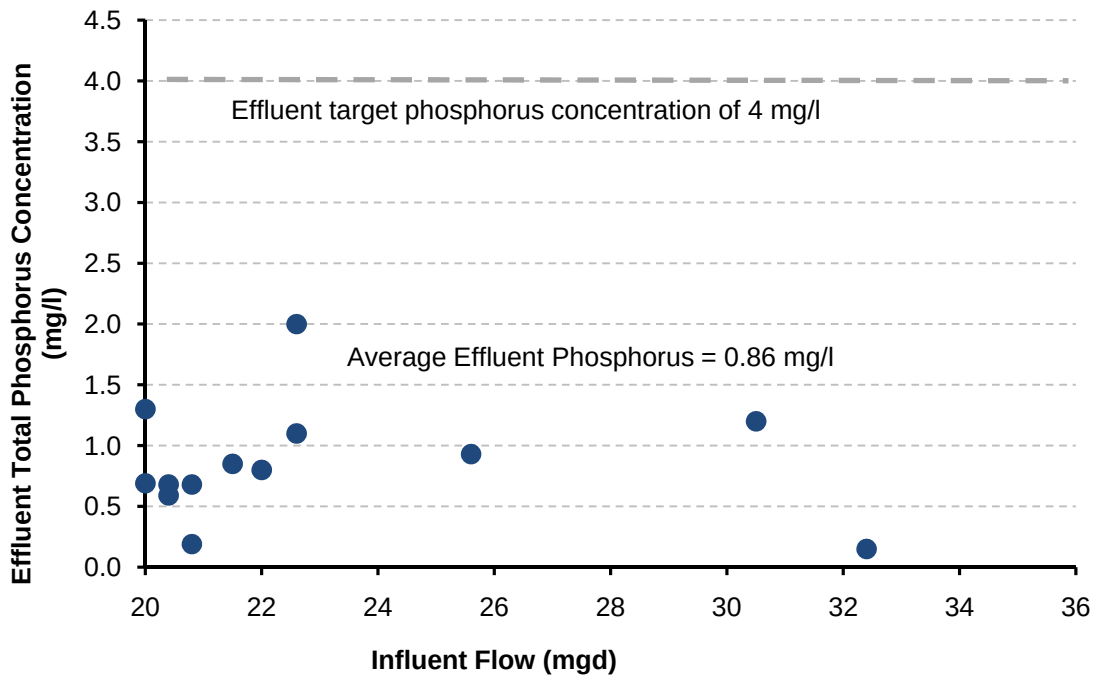


Figure 2-2: Effluent Total Phosphorus Concentration at Flow Greater Than or Equal to 20 mgd

3. Sinking Creek WWTP Process and Hydraulic Infrastructure Analysis

The objective of this section is to provide an analysis of the Sinking Creek WWTP unit processes at the current design flow of 16 mgd and at a potential re-rate flow of 20 mgd. Preliminary treatment, secondary treatment, tertiary treatment, and biosolids handling processes are addressed.

3.1 Infrastructure Summary

The Sinking Creek WWTP is a 16 mgd oxidation ditch facility with carbonaceous BOD removal and nitrification. Influent flow enters the main pump station via three interceptors from the northern, eastern, and southwest portions of the City. Raw sewage is pumped to the headworks building. The headworks facility consists of four drum screens and one vortex grit removal system. The solids collected on the screens are dewatered and transferred to a storage bin where they are held prior to being taken to a landfill for final disposal. Similarly, the grit retained in the grit removal system is drained and transported to a storage hopper until it is disposed in a landfill. The excess liquid collected from screenings and grit gravity flows to the main influent pump station. Following grit removal, flow is conveyed through a Parshall flume, located in the headworks building, before it enters the plant's biological treatment system.

Preliminary treated influent flow combines with return activated sludge (RAS) in a process influent box prior to the oxidation ditches. The biological treatment system contains two treatment trains. Each treatment train consists of an anoxic zone followed by an extended aeration oxidation ditch. The effluent of the aeration basins is equally divided between four center-feed secondary clarifiers. Waste activated sludge (WAS) is collected and pumped to sludge holding basins. Effluent flow from the final clarifiers is subsequently routed to eight deep bed sand filters. Flow is then routed to a two channel medium-pressure/high-intensity UV disinfection system. Following disinfection, effluent is transported to a dual-cell post aeration structure and an 84-inch Parshall flume before it is discharged to the West Fork Stones River. Sodium hypochlorite is added to the repurified water system before it is distributed to various land application facilities.

Biosolids handling at the plant consists of two aerated holding tanks and eight self-contained rotary presses. After dewatering, the biosolids are disposed in a local landfill. Solids handling filtrate, building drains, and preliminary treatment sidestreams flow by gravity to the influent pump station. According to plant staff, the volume and rate of this sidestream flows is not known. The plant drain pump station and filter backwash are pumped into the RAS line, which is then recycled to the process influent splitter box.

Table 3-1 provides the design criteria for each existing unit process. The design parameters were evaluated at the permitted design flow of 16 mgd.

Table 3-1: Technical Design Criteria for Existing Unit Processes at the Sinking Creek WWTP

Process	Parameter	Design Criteria
Main Influent Pump Station	Type	Variable frequency drive
	Manufacturer	Wemco
	Number of units	2
	Pump horsepower	250 HP
	Hydraulic capacity (assumed to be similar to former pump design)	2,100 – 5,800 gpm
	Type	Variable frequency drive
	Manufacturer	Wemco
	Number of units	3
	Pump horsepower	500 HP
	Hydraulic capacity	13,000 gpm
	Firm pump station capacity	50 mgd or 35,000 gpm
Rotary Drum Screens	Type	Rotary Drum
	Manufacturer	Hycor
	Number of units	4
	Screen opening	0.06 inches (1.5 mm)
	Screen diameter	3'-10"
	Firm capacity with 3 screens operating	40 mgd
	Maximum hydraulic capacity with 4 screens	50 mgd (hydraulically limited)
Grit Removal	Type	Vortex, PISTA Grit 360° 20.0 A, 20.2 B
	Number of units	1 (space for future unit)
	Diameter	16 FT
	Design operating flow	20 mgd
	Detention time at design flow	2.4 minutes
Influent Parshall Flume	Length	48 inches
Aeration Basins	Type	EIMCO Carousel Oxidation Ditch
	Number of basins	2
	HRT (total)	26 hrs
	HRT (anoxic)	4 hrs
	HRT (aerobic)	22 hrs
	SRT minimum	10 days
	Total anoxic volume	2.594 mg
	Total aerobic volume	14.526 mg
Aerators	Mixing velocity	1.0 fps
	Motor speeds	200 HP, VFD
	Oxygen transfer	3.5 lb O_2/HP•hr
	Oxygen transfer to MLSS	3.8 lb O_2/HP•hr
	Number of units per basin	3
	Total Number of units	6
	Type	Surface aerator impellers, submerged turbine
Anoxic Zone Mixers	Motor speed	35 HP
	Number of units per basin	2

Table 3-1: Technical Design Criteria for Existing Unit Processes at the Sinking Creek WWTP

Process	Parameter	Design Criteria
Secondary Clarifiers	Type	Center feed
	Number of units	4
	Diameter	145 FT
	Sidewater depth	17 FT
	Surface overflow rate, design	242 gpd/SF
	Surface overflow rate, peak	606 gpd/SF
	Solids loading rate, design	14 lb/day/SF
	Solids loading rate, peak	21 lb/day/SF
	Weir loading rate, design	8,781 gpd/FT
Filters	Type	Deep bed filtration
	Number of units	8
	Surface area, total	4,788 FT
	Surface area, per filter	598.5 FT
	Surface dimensions, per filter	9.5 FT wide, 63 FT long
	Media depth	6 FT
	Media type	Sand
	Design surface loading rate	2.32 gpm/SF at 16 mgd
	Maximum surface loading rate	5.8 gpm/SF at 40 mgd
Filter Backwash Pumps	Type	Centrifugal
	Number of units	2
	Backwash rate	Once per 48 hrs
	Backwash pump capacity	1,500 gpm
Filter Mudwell Pumps	Type	Centrifugal
	Number of units	2
Clearwell	Volume	75,000 gal
RAS Pump Station	Type	Self-priming solids handling, VFD
	Number of units	10
	Pump capacity	2,400 – 2,800 gpm
WAS Pump Station	Type	Self-priming, solids handling
	Number of units	3
	Pump capacity	700 gpm
UV Disinfection System	Type	Medium pressure / high intensity
	Manufacturer	Trojan
	Number of channels	3 (2 in use)
	Number of banks	4 (2 banks per channel)
	Design standard	126 *E. coli* per 100 ml
	Peak design flow using three channels	80 mgd
	Maximum hydraulic capacity using three channels	100 mgd
Post Aeration	Design effluent dissolved oxygen	7.2 mg/l at 40 mgd at 80°F
	Type	Submerged aspirating aerators
	Number of cells	2
	Detention time per cell at peak flow	12 minutes
	Total detention time at peak flow	24 minutes
	Cell dimensions	45 FT W x 45 FT L x 22 FT D
	Design capacity, each cell	40 mgd

Table 3-1: Technical Design Criteria for Existing Unit Processes at the Sinking Creek WWTP

Process	Parameter	Design Criteria
Repurified Water Distribution	Storage tank volume	500,000 gallons
	Pumping system capacity of each pump	5,600 gpm at 290 FT of discharge
Sludge Filter Press	Type	Rotary press
	Number of units	8
	Current dewatering capacity	26 dry tons per day
	Rated plant design capacity	24 mgd
Effluent Parshall Flume	Length	84 inches

3.2 Preliminary Treatment Facility

Influent raw sewage enters the main pump station followed by the headworks building which contains fine screens and grit removal processes. A raw sample of the wastewater is taken before the flow enters the screens as a representative sample of untreated raw sewage. However, the raw sample does include sidestream flow from the plant building drains, rotary press filtrate, and preliminary treatment. The screening process consists of four rotary drum screens each with an opening size of 0.06 inches and a hydraulic capacity of 10,200 gpm (14 mgd). The raw sewage is hydraulically divided between the four screens, which have a firm capacity of 40 mgd with one screen out of service. The channels are hydraulically limited to 50 mgd. The material collected on the screens is washed by high pressure spray rails, dewatered, and stored in a bin prior to landfill disposal.

The screens were initially installed in the late 1990s. Staff has noticed a decrease in screen reliability, particularly during sustained wet weather periods. One screen was rehabilitated in the summer of 2010 as a result of a failure. The remaining three screens are currently being replaced to increase the reliable capacity.

The current vortex grit system is sized for a 20 mgd design flow. Space is available for an additional unit. Grit settles in the center storage well and then pumped to a classifier. The grit is washed and stored in a hopper until it is eventually transported to a landfill for disposal. The water that drains from the collected screenings and grit is returned via gravity to the main influent pump station.

The preliminary treatment structure is hydraulically sized to pass a peak flow of 50 mgd. The drum screens have created operational and maintenance issues for staff, primarily due to the age of the units and wear. These screens are currently being replaced to increase reliability. For a re-rated plant flow of 20 mgd, a second grit removal unit and associated appurtenances may be necessary.

3.3 Secondary Treatment

Secondary treatment consists of two treatment trains each with an extended aeration oxidation ditch and an anoxic zone. Flow from the headworks building is combined with RAS from the secondary clarifiers in the influent splitter box structure and then hydraulically divided between the two oxidation ditches. Flow is routed to an anoxic zone followed by extended aeration. The hydraulic residence time (HRT) in each anoxic zone is four hours. The aerated HRT in the oxidation ditch is 22 hours. Each anoxic zone is equipped with two 35 horsepower (HP) mixers. Each oxidation ditch is equipped with three 200 HP mechanical submerged turbine aerators to maintain a velocity of at 1 cubic feet per second (cfs). The minimum solids retention time (SRT) is 10 days. Mixed liquor is recycled from the aerobic zone to the anoxic zone to maintain bacterial growth for the denitrification process. The effluent of the aeration basin passes over 75 feet of weir and is collected in a channel that conveys the mixed liquor flow stream to the final clarifiers.

Table 3-2 summarizes the required oxygen rates for biological nutrient removal at the current design flow of 16 mgd as well as a potential re-rated flow of 20 mgd. Total oxygen requirements were evaluated with denitrification credit at effluent nitrate concentrations of 9, 7, and 5 mg/l and without any credit for assimilative nitrogen. The results indicate that the total oxygen required at the current permit limit of 16 mgd and the re-rate flow of 20 mgd are less than the aeration equipment's delivered oxygen rate of 100,800 lb/day. Therefore, the current aeration system conservatively provides sufficient oxygen for full nitrification and CBOD oxidation. The denitrification process increases the available capacity by reducing the CBOD oxidation requirement.

Table 3-2: Summary of Oxidation Ditch Aeration Capacity Analysis

Flow	Effluent Nitrate (mg/l)	Oxygen Required for CBOD Demand (lb/d) [1, 2]	Oxygen Required for TKN Demand (lb/d) [3, 4, 5]	Oxygen Savings from Denit. (lb/d)	Total Oxygen Required w/ out Denit. (lb/d)	Total Oxygen Required w/ Denit. (lb/d)
16	9	48,038	21,811	9,923	69,849	59,927
16	7	48,038	21,811	10,686	69,849	59,163
16	5	48,038	21,811	11,449	69,849	58,400
20	9	60,048	27,263	12,403	87,311	74,908
20	7	60,048	27,263	13,357	87,311	73,954
20	5	60,048	27,263	14,311	87,311	73,000
Delivered Oxygen = 100,800 lb/d						

[1] *Calculation uses a maximum $CBOD_5$ of 300 mg/l (plant influent is less than or equal to 300 mg/l approximately 89.7 percent of the time).*
[2] *Using Oxygen Consumed:CBOD Removed ratio of 1.2.*
[3] *Using Max TKN of 35 mg/l (using estimated TKN:NH3 ratio of 1.7 and an ammonia value of 20.6 mg/l.*
[4] *Using BOD/TKN ratio of 4.67.*
[5] *Calculation does not account for assimilative nitrogen, and is therefore more conservative.*

Table 3-3 provides a summary of the biological process analysis with respect to CBOD removal and nitrification. The biological treatment process was evaluated with the existing infrastructure at the plant design flow of 16 mgd and a re-rated flow of 20 mgd. The results indicate that the design HRT for 16 and 20 mgd is greater than the calculated design minimums for CBOD oxidation and nitrification. The peak hour HRT at peak flow is marginal for 16 and 20 mgd, but the minimum treatment time does depend on temperature and the plant operating characteristics. The plant currently fully nitrifies and oxidizes CBOD at peak flow. Additionally, the average and monthly F/M at design and peak hour flow are greater than the recommended range for extended aeration oxidation ditches. The calculated SRT for nitrification is close to the minimum suggested SRT required for nitrification at a temperature of 12°C. The minimum influent monthly average temperature in the Sinking Creek WWTP data set was 13.7°C. Additionally, the minimum design SRT is 10 days. In summary, the plant has sufficient biological capacity for CBOD oxidation and nitrification at the existing design flow of 16 mgd and a re-rated flow of 20 mgd.

Table 3-3: Biological Process Analysis for BOD Removal and Nitrification

	Hydraulic Residence Time, HRT (hour)	Average F/M (lb BOD applied/ lb MLVSS·d)	Monthly Max F/M (lb BOD applied/ lb MLVSS·d)	Calculated SRT for Nitrification (day)	Req. HRT for Avg. BOD Load (hour)	Req. HRT for Monthly Max BOD Load (hour)
Design Flow of 16 mgd:						
$Q_{minimum\ month}$	32.6	0.054	0.078	7.3	6.1	8.7
$Q_{Average}$	24.9	0.071	0.102	7.3	6.1	8.7
Q_{Design}	25.7	0.069	0.099	7.3	6.1	8.7
$Q_{Design,\ peak}$	10.3	0.275	0.394	7.1	6.1	8.7
$Q_{Peak\ hour}$	8.2	0.343	0.492	7.0	6.1	8.7
Re-Rated Flow of 20 mgd:						
Q_{Design}	20.5	0.086	0.124	7.3	6.1	8.7
$Q_{Design,\ peak}$	8.2	0.343	0.492	7.0	6.1	8.7
Design Criteria	10 to 12 hours in cold temperature (for nitrification)	0.04 – 0.10 [2]		8 [3]	Compare against volumetric HRT	

[1] *Recommended hydraulic residence time (HRT) for oxidation ditch with commonly used nitrogen-removal processes, from Metcalf and Eddy.*
[2] *Metcalf and Eddy design criteria for plug flow oxidation ditch.*
[3] *Calculated minimum solids retention time (SRT) for ammonia oxidation in cold temperatures (12°C).*

3.4 Secondary Clarification

The secondary clarification system consists of four center-feed clarifiers. Each clarifier is 145 feet in diameter and has a side water depth of 17 feet. Each clarifier is equipped with an algae sweep to collect floatables, as well as to clean the weirs and scum baffles. The settled MLSS is collected using a spiral scraper. Each clarifier is also equipped with a Stamford baffle.

The secondary clarifiers were evaluated for surface overflow rate, weir loading rate, and solids loading rate. The analysis is provided in Table 3-4. The surface overflow rates are within acceptable design criteria at design and peak flow for 16 and 20 mgd. While the weir loading rate is not a critical design parameter for secondary clarifiers, it is important to note that the loading rates are in an acceptable range at all flows except for design peak and peak hourly flow, at which the weir loading rates are slightly marginal. The solids loading rate calculation is one of the most critical design parameters for secondary clarifiers. The solids loading rate calculations were calculated based on an MLSS of 3,500 mg/l at design flow and 2,200 mg/l at peak flow. At the design flow of 16 mgd and a re-rated flow of 20 mgd, the calculated solids loading rates are within acceptable design criteria.

Table 3-4: Secondary Clarifier Process Analysis

	Flow per Clarifier [1, 2] (mgd)	Surface Overflow Rate per Clarifier (gpd/SF)	Weir Loading Rate per Clarifier (gpd/FT)	Solids Loading Rate per Clarifier (lb/SF·d) [3]
Design Flow of 16 mgd:				
$Q_{minimum\ month}$	3.2	191	6,915	11
$Q_{Average}$	4.1	250	9,055	15
Q_{Design}	4.0	242	8,781	14
$Q_{Design,\ peak}$	10.0	606	21,952	21
$Q_{Peak\ hour}$	12.5	757	27,441	26
Re-Rated Flow of 20 mgd:				
Q_{Design}	5.0	303	10,976	18
$Q_{Design,\ peak}$	12.5	757	27,441	27
Metcalf & Eddy Design Criteria	Average	200 – 400	< 20,000 [4]	4.8 – 24.0
	Peak	600 – 800		33.6
TDEC Design Criteria	Average	400	<15,000	25
	Peak	1,000		35

[1] *Assumes four clarifiers are in service.*
[2] *A recycle flow of 1*Q was used for design flow and ½Q for peak flow.*
[3] *An MLSS concentration of 3,500 mg/l was used for design flow and 2,200 mg/l was used for peak flow.*
[4] *Weir loading rate should be less than 30,000 gpd/ft when located away from upturn zone of the density current and less than 20,000 gpd/ft when located within the upturn zone.*

The secondary clarifiers are occasionally producing a cloudy and turbid effluent. Historic SVI values have steadily increased, indicating a decline in sludge settling quality. There are several factors that may be causing this phenomenon, two of which are discussed in this section. The first issue is an increase in the monovalent-to-divalent cation ratio in the activated sludge. In a sludge floc, the bacterial cells excrete biopolymer material (e.g. proteins and polysaccharides), which help hold the bacterial cells together in the floc. These biopolymers are negatively charged. Positively charged ions therefore act as a bridge between the biopolymer material. Divalent cations, such as calcium and magnesium, have two points of charge and provide a stronger bridge mechanism to bind biopolymer. Monovalent cations, such as sodium or potassium, only have one point of charge and do not form as strong of a bridging mechanism. A higher ratio of monovalent cations to divalent cations results in a poorer settling sludge and effluent quality. The process may be reversed by increasing the divalent to monovalent cation ratio. This can be accomplished with the addition of a divalent salt, such as magnesium hydroxide, directly to the influent.

The second possible reason for poor quality effluent from the secondary clarifier is that the sludge may not be exposed to a truly anoxic or anaerobic environment. In prolonged anaerobic or anoxic conditions, microbes in sludge excrete more protein biopolymers than polysaccharide biopolymers. Protein biopolymers produce better settling sludge because they are longer and have more extended structures than the polysaccharide biopolymers. Therefore, treatment plants with anoxic or anaerobic selectors typically experience better settling sludge. Additionally, the F/M ratio also assists in anoxic and anaerobic selector performance. A higher F/M ratio will drive the rate of soluble substrate uptake in the anoxic or anaerobic environment, which improves protein biopolymer excretion and sludge settleability.

3.5 Tertiary Filtration

Tertiary filtration at the Sinking Creek WWTP consists of eight deep bed sand filters. The filters are designed for a maximum capacity of 40 mgd at a filtration rate of 5.8 gpm/SF with all filters in service. The filters have been designed for denitrification capability, although an external carbon source is currently not installed. A mix of effluent and air scour is used to clean the sand media. Spent backwash water is routed to a mudwell, and then pumped to the RAS line. Backwashing occurs every 48 hours at a pumping rate of 1,500 gpm.

The process evaluation for the tertiary filters is provided in Table 3-5. At a plant design flow of 16 mgd with all filters in service, the surface overflow rate is within the acceptable design criteria range. At the current peak hour flow, the surface overflow rate meets acceptable design criteria, but is at the upper end of the range. With one filter out of service, the surface overflow rates are on the very high end of the design criteria. The peak day condition with all filters in service will control the filter hydraulic design; however, if the filters are activated for denitrification, then the kinetic design will control in colder temperatures. Typically, deep bed filters actively used for denitrification are designed with a surface overflow rate of 2 gpm/SF at the plant design flow.

At the plant re-rated flow of 20 mgd, the surface overflow rates are within the upper range of acceptable design criteria. Plant staff has indicated that 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 filter process reliability. Lowering the design surface overflow rate will also accommodate the future denitrification, if necessary.

Table 3-5: Tertiary Filtration Process Analysis

	Flow per Filter, mgd	Surface Overflow Rate, gpm/SF (all filters in service)	Surface Overflow Rate, gpm/SF (one filter out of service)
Design Flow of 16 mgd:			
$Q_{minimum\ month}$	1.58	1.83	2.09
$Q_{Average}$	2.06	2.39	2.74
Q_{Design}	2.00	2.32	2.65
$Q_{Design,\ peak}$	5.00	5.80	6.63
$Q_{Peak\ hour}$	6.25	7.25	8.29
Re-Rated Flow of 20 mgd:			
Q_{Design}	2.50	2.90	3.32
$Q_{Design,\ peak}$	6.25	7.25	8.29
Metcalf & Eddy Design Criteria	Average	5	5
	Peak	9	9
Hazen and Sawyer Criteria for Denitrification	Average	2 to 3	
	Peak	5 to 6	
TDEC Design Criteria	Average	< 4 [1]	< 4 [1]

[1] *TDEC requires the maximum filtration rate to be 4 gpm/SF immediately after backwash with a nominal rate of less than 4 gpm/SF at the peak daily flow (for high rate gravity filters).*

3.6 UV Disinfection

The UV disinfection system at the Sinking Creek WWTP is a medium-pressure/high-intensity system by Trojan Technologies. The equipment was installed in the late 1990s. The UV equipment is installed in two out of three existing channels. The maximum hydraulic channel capacity is 100 mgd. Based on the microbial inactivation reported for the plant effluent, the UV system is operating properly. No coliform violations have occurred in the last three years. The existing hydraulic structure and UV equipment are adequately sized to accommodate a plant re-rated flow of 20 mgd.

However, staff does have difficulty turning down lamps during minimum flow events. There is also concern that the age of the equipment may affect process reliability. It is recommended that a detailed low-pressure/high-intensity versus medium-pressure/high intensity equipment analysis be performed prior to the next capital improvements project to assess the cost effectiveness of installing a new low-pressure / high-intensity UV system.

3.7 Post Aeration

The post aeration structure is a dual-cell unit. Submerged aspirating aerators are designed to provide effluent with a dissolved oxygen content of 7.2 mg/l at 40 mgd and a temperature of 80°F. Currently, the plant effluent water quality exceeds the permitted dissolved oxygen concentration of 6 mg/l with a total detention time of 24 minutes at a peak flow of 40 mgd. At a plant re-rated flow of 20 mgd, the total detention time at a peak flow of 50 mgd is 20 minutes. Additional aeration units will not be required for a plant re-rerated flow of 20 mgd.

3.8 Solids Handling

The Sinking Creek WWTP designed and commissioned a biosolids handling facility in 2006. The biosolids design consists of aerobic solids holding tanks and eight self-contained rotary presses for dewatering. The rotary presses typically produce sludge of approximately 14 percent solids but may be optimized to achieve higher percent solids. The capacity of the dewatering system is 26 dry tons per day, or an equivalent plant capacity of 24 mgd. There is adequate solids handling capability for a plant re-rated flow of 20 mgd; however, if chemical precipitation for phosphorus removal is required, then the dewatering capacity should be confirmed for handling the increased solids concentration. Press filtrate is returned to the plant influent pump station.

Dewatered solids are disposed in a local landfill. Landfill disposal is a very economical alternative for the City. The City agreed to treat the landfill leachate in exchange for a waiver of landfill tipping fees. The City is not actively pursuing other biosolids management options. However, in the event the landfill closes or regulations require an alternative biosolids disposal method, there are many options available to the City for Class A or Class B solids treatment. TM 3 discusses these options in detail.

4. Sinking Creek WWTP Expansion Alternatives

4.1 Summary of Expansion Alternatives

There are several capacity expansion alternatives that can be considered at the Sinking Creek WWTP location. All of these capacity expansion alternatives have distinct advantages and disadvantages with respect to treatment reliability, influent flow equalization, and effluent disposal. However, there are three expansion alternatives that utilize the unit process rated capacity in even expansion increments. These capacity expansion alternatives and their corresponding advantages and disadvantages are described as follows:

1. **Hydraulic and process re-rate of Sinking Creek WWTP to 20 mgd without a physical expansion of plant infrastructure:**
   - Based on the data analysis in Section 3, it may be possible for the facility to reliably operate under the current permit at a total nitrogen threshold of 1,201 lb/day without significant modifications to the existing treatment process.
   - The preliminary analysis indicates that the existing process can be re-rated from 16 to 20 mgd without a compromise in treatment performance or reliability.
   - The increase in rated flow will decrease the flow equalization capability of the oxidation ditches.
   - A satellite facility(s) will be required to accommodate additional growth and wastewater capacity needs in the service area.
   - Activating the tertiary filters for denitrification should be considered for total nitrogen removal reliability.
   - Additional tertiary filtration capacity should be evaluated to increase reliability, even if filters are not activated for denitrification.
   - An additional vortex grit removal unit may need to be considered.
   - Effluent phosphorus concentrations should continue to be monitored. Although current treatment trends predict compliance with current loading criteria, chemical precipitation for phosphorus removal may be required.
   - The re-rating options result in a decreased capital cost associated with a process and hydraulic re-rate of existing infrastructure.

2. **Expansion of Sinking Creek WWTP to 24 mgd with the construction of one additional oxidation ditch:**
   - Process modifications will be necessary to operate under the current permit at a total nitrogen threshold of 1,201 lb/day.
     - The existing extended aeration process could be modified with activation of the tertiary filters for denitrification and/or the construction of an upstream anoxic basin (see TM 3 for the MLE configuration).
     - Another option is to maintain the existing extended aeration process and blend effluent flow from a parallel advanced nutrient removal sidestream facility achieving an effluent quality of 2 mg/l of total nitrogen (reference Table 1-2).
   - The oxidation ditches may continue to function as flow equalization and treatment.
   - Chemical precipitation for phosphorus removal may be required.
   - A satellite facility(s) will be required to accommodate additional growth and wastewater capacity needs in the service area.
     - Due to the impaired water issues in West Fork Stones River, the expansion of the Sinking Creek WWTP will require that land application be pursued for effluent disposal.
3. **Expansion of the Sinking Creek WWTP to 32 mgd with the construction of two additional oxidation ditches:**
   - Process modifications will be necessary to operate under the current permit at a total nitrogen threshold of 1,201 lb/day.
     - Modifications could include conversion of the existing extended aeration process to a 5-stage advanced nutrient removal process to achieve an effluent total nitrogen concentration of 4 mg/l.
     - Either biological or chemical phosphorus removal may be used.
   - The influent flow equalization capacity of the oxidation ditches will be significantly decreased.
   - A satellite facility(s) will not be required to accommodate additional growth and wastewater capacity needs in the service area.
     - Due to the impaired water issues in West Fork Stones River, the expansion of the Sinking Creek WWTP will require that land application be pursued for effluent disposal.

4.2 Recommendations for Future Sampling, Re-Rate Analysis, and Process Improvements

It is recommended that the City move forward with a detailed re-rate evaluation of the Sinking Creek WWTP. This detailed evaluation is required as part of the application to TDEC for an expanded surface water discharge in West Fork Stones River. The re-rate evaluation should provide a biological process model, a hydraulic model, and expanded discussions of unit process reliability. The re-rate evaluation will be required to demonstrate to TDEC that the existing unit processes can reliably meet the effluent discharge permit limits.

It is recommended that the City initiate a detailed plant sampling protocol to properly characterize the influent flow prior to the biological process modeling effort. The influent characterization would include determining the soluble and particulate influent fractions for carbon, nitrogen, and phosphorus. The detailed influent characterization will enable an accurate process model to be built, verified, and calibrated. Additionally, the solids handling sidestream should be characterized to assess the impact to the mainstream process.

The current treatment evaluation has revealed some significant process challenges at the Sinking Creek WWTP. First, the influent dissolved oxygen is extremely high. These elevated dissolved oxygen concentrations will significantly affect the ability of a future nutrient removal process to reliably remove nitrogen and/or phosphorus. It is recommended that a detailed dissolved oxygen profile be performed throughout the plant and possibly the collection system. Second, the plant experiences frequent sludge settling problems due to a cloudy, or pin-point, floc. Several reasons for the settling issues are discussed in Section 3.4. It is recommended that the City continue to pursue potential solutions to the clarifier settling issue.

5. Analysis of Decentralized Treatment Alternatives

A second alternative to a capacity expansion of the Sinking Creek WWTP is the development of a decentralized wastewater treatment system. The two primary drivers for considering decentralized treatment are 1) locate the treatment plant near the effluent disposal 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. For the purposes of this project, the location and efficacy of one or more decentralized treatment facilities are evaluated. After recommendations are outlined regarding the size and number of decentralized facilities, the use of a scalping plant or stand-alone plant will be discussed.

5.1 Determination of Potential Satellite Facility Locations

Twelve potential locations for decentralized satellite treatment facilities were identified using data previously prepared as part of this project and using information presented by MWSD, including:

- The geographic distribution of baseline (2010) wastewater flow rates (TM 1).
- The geographic distribution of projected 20-year (2030) wastewater flow rates (TM 1).
- The location of existing major interceptors.
- The location of sewer infrastructure improvements proposed in the 2002 Wastewater Facilities Plan.
- Current and potential land application sites that were based on review of size and soil favorability of properties (TM 4 and previous site evaluation from MWSD).
- The Thompson Lane chronic overflow location and previously identified sites for regional pump stations to relieve flow from this area.

The figures in TM 1 describing the geographic distribution of wastewater flow within the service area were used to determine suitable locations for satellite facilities that could accommodate current and future flow requirements. The land application effluent disposal (i.e., zero discharge) options discussed in TM 4 were used to determine potential satellite facility locations that would be in close proximity to potential land disposal sites. Additionally, the Thompson Lane overflow information provided by the City included recommendations for two locations for either satellite treatment facilities (northeast and southwest) or regional pump stations with parallel force mains to shed flow from the Sinking Creek and Stones River interceptors. These two 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 satellite facilities were identified using the aforementioned criteria. These locations are illustrated in Figure 5-1. Figure 5-2 illustrates the sewer district service area delineations for each of the twelve

satellite facilities. Table 5-1 provides a summary of the estimated 2010 and 2030 wastewater flow rates to each satellite facility in accordance with the data presented in TM 1.

Table 5-1: Current and Projected Service Area Wastewater Flow to Proposed Satellite Facilities

Satellite Facility Number	Sewer Districts Served	2010 Flow (mgd)			2030 Flow (mgd)		
		AADF [1]	MM	PD	AADF	MM	PD
S1	21, 22, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 45, 46, 48, 49, 51, 52, 70, 71, 72, 96, 100	4.03	5.51	10.53	8.70	11.90	23.71
S2	64, 65, 66, 101, 118, 119, 120, 121, 122, 123	0.61	0.79	1.53	1.11	1.42	2.76
S3	10, 12, 15, 16, 32	2.22	3.95	9.30	2.89	5.11	12.00
S4	55, 68, 73, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 97, 98, 99, 102, 104, 106, 107, 109, 110, 112, 113, 115, 116, 117, 124, 125	1.66	2.56	8.09	4.00	6.07	18.32
S5	91, 97, 90, 92, 93, 94, 95, 98	0.47	0.76	2.76	1.42	2.29	8.26
S6	39, 70, 100, 35, 71, 96	1.94	2.58	5.31	4.75	6.36	13.85
S7	108, 111, 118, 119, 66	0.18	0.23	0.44	0.33	0.43	0.83
S8	88, 89, 90, 91, 92, 93, 94, 95, 97, 98	1.21	1.95	6.96	2.56	4.14	14.71
S9	100, 70	1.05	1.40	2.96	3.30	4.43	10.01
S10	9, 59, 62, 64	1.76	2.66	5.43	2.88	4.37	8.87
S11	All districts for Facility No. S1 plus 7, 17, 18, 19, 20, 23, 25, 26, 27, 28, 30, 53, 63, 114	6.41	9.12	16.70	11.66	16.37	31.33
S12 [2]	107, 109, 110, 112, 113, 115, 116, 117, 124, 125	0.00	0.00	0.00	0.00	0.00	0.00

[1] *AADF = Average Annual Daily Flow, MM = Maximum Month Flow, PD = Peak Day Flow*
[2] *Population in the districts served by S12 are not projected to be sewered until after 2030.*

5.2 Description of Satellite Facility Capacity and Effluent Disposal Options

Each identified satellite facility location has advantages and disadvantages in terms of service area disposal options, and relief of current collection system capacity limitations. The potential satellite facility sites are detailed in the following subsections. Each subsection provides a brief description of the proposed satellite plant capacity and the potential effluent disposal options, including an evaluation of land application location options. The land application effluent disposal options were initially presented in TM 4, and are illustrated in Figure 5-3. The land application locations are designated as "L#." In the following descriptions, the terminology of "L#/L#/L#" for the land application location options indicates that any combination of one, two, or three of the listed options could be selected depending on the required plant capacity. The discussion also includes the potential for a seasonal surface water discharge permit as well as the ultimate land application capacity (e.g., during warm-weather months, all flow must be land applied). The land application capacity was evaluated for both spray irrigation and subsurface drip disposal, with the capacity difference being the result of different buffer requirements between the two methods (reference TM 4). Figures 5-1, 5-2, and 5-3 should be referenced for the following satellite facility descriptions and effluent disposal locations.

5.2.1 Satellite Facility Site No. S1

Site S1 was previously identified by the City for a potential treatment facility or a southwest regional pump station. This site had been selected to alleviate flow from the Stones River interceptor and to service both existing and new flow in the southern portion of the service area. A summary of pertinent information for site S1 is as follows:

- Proposed plant capacity ratings:
  - 9.0 mgd annual average daily flow (AADF)
  - 12.0 mgd maximum month daily flow (MM)
- Effluent disposal options (based on maximum month plant capacity):
  - <u>Option S1-A</u>: Land application to any combination of L1/L2/L3.
    - Spray Irrigation – Land capacity is not sufficient.
    - Subsurface Drip – Land capacity is not sufficient.
  - <u>Option S1-B</u>: Land application to any combination of L4/L5/L6.
    - Spray Irrigation – Land capacity is not sufficient.
    - Subsurface Drip – Land capacity is not sufficient.
  - <u>Option S1-C</u>: Land application to any combination of L1/L2/L3/L4/L5/L6.
    - Spray Irrigation – Land capacity is not sufficient.
    - Subsurface Drip – The plant flow rate would require five properties (all

with location L4 included). A capacity of 11.9 mgd could be achieved if four properties (i.e., L4/L5/L1/L2) are used.

- The effluent from proposed satellite facility S1 could be pumped to the existing outfall, seasonally or continuously discharged into the East Fork of the Stones River (Outfall #002 – Reference TM 2), or land applied at the Jordan or Coleman Farms or at new land application property locations (L8, L9, L10, and/or L11) as identified in the northeast area. However, if effluent needs to be pumped over a long distance to the northeast, other effluent disposal options, such as expanding the Sinking Creek WWTP, may be more favorable. This reasoning is applicable for all proposed satellite facilities in the southwest and southeast portions of the service area.

5.2.2 Satellite Facility Site No. S2

Site S2 was previously identified by the City for a potential treatment facility or northeast regional pump station. This site was selected to alleviate flow from the Compton Road pump station and ultimately the Sinking Creek interceptor. This satellite facility option would accommodate both existing and new flow requirements in the northeast portion of the service area. A summary of pertinent information for site S2 is as follows:

- Proposed plant capacity ratings:
  - 1.5 mgd annual average daily flow (AADF)
  - 2.0 mgd maximum month daily flow (MM)
- Effluent disposal options (based on maximum month plant capacity):
  - <u>Option S2-A</u>: Continuous discharge into the East Fork Stones River (#002).
  - <u>Option S2-B</u>: Seasonal discharge into East Fork (#002) and land application at Jordan Farm, Coleman Farm, location L8, and/or locations L9/L10/L11.
    - Spray Irrigation – Land application location L9 or L10 alone would be sufficient for flow capacity. Otherwise, any combination of two locations would be required.
    - Subsurface Drip – Most combinations of land application locations are sufficient for flow capacity except Jordan Farm alone.
  - <u>Option S2-C</u>: Land application only (without a seasonal discharge permit) at Jordan Farm, Coleman Farm, Location 8, and/or Locations L9/L10/L11.
    - Spray Irrigation – Land application location L9 or L10 alone would be sufficient for flow capacity. Otherwise, any combination of two locations would be required.

- Subsurface Drip – Most combinations of land application locations are sufficient for flow capacity except Jordan Farm alone.

5.2.3 Satellite Facility Site No. S3

Site S3 was proposed to serve the existing and proposed wastewater flow east of the city and near the city-center and includes a portion of the Middle Tennessee State University area. This site location was also intended to relieve flow from the Sinking Creek interceptor. A summary of pertinent information for site S3 is as follows:

- Proposed plant capacity ratings:
  - 3.0 mgd annual average daily flow (AADF)
  - 5.5 mgd maximum month daily flow (MM)
- Effluent disposal options (based on maximum month plant capacity):
  - Option S3-A: Continuous discharge into the East Fork Stones River (#002).
  - Option S3-B: Seasonal discharge into East Fork Stones River (#002) and land application at Jordan Farm, Coleman Farm, location L8, and/or locations L9/L10/L11.
    - Spray Irrigation – If spray irrigation is used on the Jordan and Coleman Farms for S3 effluent, the addition of either location L9 or a combination of two properties from L8/L10/L11 would provide sufficient capacity. Otherwise, locations L9 and L10 or locations L9 and L8 would be required for adequate capacity.
    - Subsurface Drip – If spray irrigation is used on the Jordan and Coleman Farms for S3 effluent, the addition of L8, L9, or L10 would provide adequate capacity. Otherwise, location L9 or any combination of two properties from L8/L10/L11 would be required.
  - Option S3-C: Land application only (without a seasonal discharge permit) at Jordan Farm, Coleman Farm, location L8, and/or locations L9/L10/L11.
    - Spray Irrigation – If spray irrigation is used on the Jordan and Coleman Farms for S3 effluent, the addition of either location L9 or a combination of two properties from L8/L10/L11 would provide sufficient capacity. Otherwise, locations L9 and L10 or locations L9 and L8 would be required for adequate capacity.
    - Subsurface Drip – If spray irrigation is used on the Jordan and Coleman Farms for S3 effluent, the addition of L8, L9, or L10 would provide adequate capacity. Otherwise, location L9 or any combination of two properties from L8/L10/L11 would be required.

5.2.4 Satellite Facility Site No. S4

Site S4 is located near the Overall Creek pump station and is intended to serve the Overall Creek basin, including those areas proposed for development of infrastructure north of the existing pump station (per the 2002 Wastewater Facilities Plan). Pumping all of the Overall Creek basin flow to the Sinking Creek WWTP could be avoided with the construction of a satellite facility at this location. Since TDEC has shown resistance to allowing a new surface water discharge into Overall Creek, the effluent disposal options are limited to developing a new land application property at location L7. A summary of pertinent information for site S4 is as follows:

- Proposed plant capacity ratings:
  - 4.0 mgd annual average daily flow (AADF)
  - 6.0 mgd maximum month daily flow (MM)
- Effluent disposal options (based on maximum month plant capacity):
  - Option S4-A: Land application (all effluent and 12 month/year) at location L7.
    - Spray Irrigation – Location L7 alone (capacity of 1.5 mgd) is not sufficient for this plant size.
    - Subsurface Drip – Location L7 alone (capacity of 2.3 mgd) is not sufficient for this plant size.
  - If spray irrigation is used on the Jordan and Coleman Farms for S4 effluent and location L7 is developed as a sub-surface disposal system, the maximum plant capacity would be limited to 5.1 mgd.

5.2.5 Satellite Facility Site No. S5

Site S5 was intended to serve existing and new development in the southwest corner of the service area. This site is located near the proposed land application sites L1, L2, and L3. A summary of pertinent information for site S5 is as follows:

- Proposed plant capacity ratings:
  - 1.5 mgd annual average daily flow (AADF)
  - 2.5 mgd maximum month daily flow (MM)
- Effluent disposal options (based on maximum month plant capacity):
  - Option S5-A: Land application to any combination of one, two, or three properties from locations L1, L2, and L3 (L1/L2/L3).
    - Spray Irrigation – A minimum of two of the three properties would be needed for adequate capacity.

        - Subsurface Drip – A minimum of two of the three properties would be needed for adequate capacity.
    - Option S5-B: Land application to any combination of L4/L5/L6.
        - Spray Irrigation – Either location L4 or both locations L5 and L6 would be required.
        - Subsurface Drip – Location L4, location L5, or a combination of location L6 plus another property would be required.

5.2.6 Satellite Facility Site No. S6

The satellite facility site S6 was selected to serve the proposed sewer line extensions on the south end of the service area. This site would primarily serve future growth, but this location would also divert a portion of existing flow from the Stones River interceptor. A summary of information for site S6 is as follows:

- Proposed plant capacity ratings:
    - 5.0 mgd annual average daily flow (AADF)
    - 6.5 mgd maximum month daily flow (MM)
- Effluent disposal options (based on maximum month plant capacity):
    - Option S6-A: Land application to any combination of one, two, or three properties from L1, L2, and L3 (L1/L2/L3).
        - Spray Irrigation – Land capacity is not sufficient. A capacity of 5.9 mgd could be achieved if all three properties are used.
        - Subsurface Drip – A minimum of two properties would be required if location L4 is used, i.e., only L4 and L5 or L4 and L6 will provide adequate capacity.
    - Option S6-B: Land application to any combination of L4/L5/L6.
        - Spray Irrigation – Land capacity is not sufficient.
        - Subsurface Drip – Land capacity is not sufficient.
    - Option S6-A does not provide sufficient capacity; however, locations L1/L2/L3 could be used in combination with locations L4/L5/L6.

5.2.7 Satellite Facility Site No. S7

Site S7 would serve the northern portions of the service area and is intended to eliminate the need to pump from the three existing and proposed pump stations at the northern edge of sewer districts 66 and

108. This site is located immediately adjacent to the Coleman Farm, which could serve as the primary effluent disposal location. A summary of pertinent information for site S7 is as follows:

- Proposed plant capacity ratings:
  - 0.5 mgd annual average daily flow (AADF)
  - 1.0 mgd maximum month daily flow (MM)
- Effluent disposal options (based on maximum month plant capacity):
  - Option S7-A: Continuous discharge into the East Fork Stones River (#002).
  - Option S7-B: Seasonal discharge into East Fork Stones River (#002) and land application at Jordan Farm, Coleman Farm, location L8, and/or locations L9/L10/L11.
    - Spray Irrigation – Any one property of the choices available (Jordan Farm, Coleman Farm, L8/L9/L10/L11) would suffice for the proposed plant size.
    - Subsurface Drip – Any one property of the choices available (Jordan Farm, Coleman Farm, L8/L9/L10/L11) would suffice for the proposed plant size.
  - Option S7-C: Land application only (without a seasonal discharge permit) at Jordan Farm, Coleman Farm, location L8, and/or locations L9/L10/L11.
    - Spray Irrigation – Any one property of the choices available (Jordan Farm, Coleman Farm, L8/L9/L10/L11) would suffice for the proposed plant size.
    - Subsurface Drip – Any one property of the choices available (Jordan Farm, Coleman Farm, L8/L9/L10/L11) would suffice for the proposed plant size.

5.2.8 Satellite Facility Site No. S8

Site S8 was intended to serve the existing and projected growth in the western and southwestern portions of the service area. This location would collect flow from the southern half of the Overall Creek sewershed. A new surface water discharge in Overall Creek is not favored by TDEC, so this effluent disposal option would not be feasible. A summary of pertinent information for site S8 is as follows:

- Proposed plant capacity ratings:
  - 3.0 mgd annual average daily flow (AADF)
  - 4.5 mgd maximum month daily flow (MM)

- Effluent disposal options (based on maximum month plant capacity):
    - Option S8-A: Land application (all effluent and 12 months/year) at location L7.
        - Spray Irrigation – Location L7 alone (capacity of 1.5 mgd) is not sufficient for this plant size.
        - Subsurface Drip – Location L7 alone (capacity of 2.3 mgd) is not sufficient for this plant size.
    - Option S8-B: Land application to any combination of one, two, or three properties from locations L1, L2, and L3 (L1/L2/L3).
        - Spray Irrigation – Locations L1/L2/L3 together do not provide sufficient disposal capacity. A capacity of 3.8 mgd could be achieved if all three properties are used.
        - Subsurface Drip – All three properties would be required to provide adequate disposal capacity. A capacity of 4.2 mgd could be achieved if only locations L1 and L2 are used together.

5.2.9 Satellite Facility Site No. S9

Site S9 was selected to be near the potential land application locations L4, L5, and L6. This satellite facility site would serve the existing and proposed flows in the southeast corner of the service area. A summary of pertinent information for site S9 is as follows:

- Proposed plant capacity ratings:
    - 3.5 mgd annual average daily flow (AADF)
    - 4.5 mgd maximum month daily flow (MM)
- Effluent disposal options (based on maximum month plant capacity):
    - Option S9-A: Land application (all effluent and 12 months/year) to any combination of locations L4/L5/L6.
        - Spray Irrigation – Both locations L4 and L5 would be required for sufficient flow capacity.
        - Subsurface Drip – Either location L4 or a combination of both locations L5 and L6 would be required.

5.2.10 Satellite Facility Site No. S10

Site S10 was selected to serve flow from the eastern section of the service area including the northern portion of the Middle Tennessee State University area. A summary of pertinent information for site S10 is as follows:

- Proposed plant capacity ratings:
  - 3.0 mgd annual average daily flow (AADF)
  - 4.5 mgd maximum month daily flow (MM)
- Effluent disposal options (based on maximum month plant capacity):
  - Option S10-A: Continuous discharge into the East Fork Stones River (#002).
  - Option S10-B: Seasonal discharge into East Fork (#002) and land application at Jordan Farm, Coleman Farm, location L8, and/or locations L9/L10/L11.
    - Spray Irrigation – If spray irrigation on the Jordan and Coleman Farms is used for S10 effluent (i.e., 4.5 mgd total effluent less 2.8 mgd on Jordan/Coleman Farms equals 1.7 mgd additional capacity required), any one of the locations L8, L9, or L10 will suffice. For 4.5 mgd of land application capacity, location L9 plus any one other location from L8, L10, and L11 would be required.
    - Subsurface Drip – If spray irrigation is used on the Jordan and Coleman Farms for S10 effluent, any one of the locations L8, L9, L10, or L11 will suffice. For 4.5 mgd of land application capacity, either location L9 or any combination of two locations from L8, L10, and L11 would be required.
  - Option S10-C: Land application only (without a seasonal discharge permit) at Jordan Farm, Coleman Farm, location L8, and/or locations L9/L10/L11.
    - Spray Irrigation – If spray irrigation is used on the Jordan and Coleman Farms for S10 effluent (i.e., an additional 1.7 mgd of capacity would be needed), any one of the locations L8, L9, or L10 will suffice. For 4.5 mgd of land application capacity, location L9 plus any one other location from L8, L10, and L11 would be required.
    - Subsurface Drip – If spray irrigation is used on the Jordan and Coleman Farms for S10 effluent, any one of the locations L8, L9, L10, or L11 will suffice. For 4.5 mgd of land application capacity, either location L9 or any combination of two locations from L8, L10, and L11 would be required.

5.2.11 Satellite Facility Site No. S11

Site S11 is similar to site S1, but was relocated east to collect additional existing and future flow from the upstream reaches of the Stones River interceptor. A summary of pertinent information for site S11 is as follows:

- Proposed plant capacity ratings:
  - 12.0 mgd annual average daily flow (AADF)
  - 16.5 mgd maximum month daily flow (MM)
- Effluent disposal options (based on maximum month plant capacity):
  - Option S11-A: Land application to any combination of one, two, or three properties from locations L1, L2, and 3 (L1/L2/L3).
    - Spray Irrigation – Land capacity is not sufficient.
    - Subsurface Drip – Land capacity is not sufficient.
  - Option S11-B: Land application to any combination of locations L4/L5/L6.
    - Spray Irrigation – Land capacity is not sufficient.
    - Subsurface Drip – Land capacity is not sufficient.
  - Option S11-C: Land application to any combination of locations L1/L2/L3/L4/L5/L6.
    - Spray Irrigation – Land capacity is not sufficient.
    - Subsurface Drip – Land capacity is not sufficient.
  - Even if all six properties (L1 to L6) are developed with subsurface disposal systems, the capacity would be limited to 15.6 mgd. Spray irrigation on all six properties would yield 9.7 mgd.

5.2.12 Satellite Facility Site No. S12

Site S12 is intended to serve the future development and proposed sewer extensions in the north and northwest portion of the service area. Similar to Site S4, TDEC has shown resistance to allowing a new surface water discharge outfall into the stream reaches near the confluence of Overall Creek and the Stones River. Therefore, the effluent disposal alternatives are limited to developing a new land application site at location L7. A summary of pertinent information for site S12 is as follows:

- Proposed plant capacity ratings:
  - 2.0 mgd annual average daily flow (AADF)
  - 3.0 mgd maximum month daily flow (MM)

- Effluent disposal options (based on maximum month plant capacity):
    - Option S12-A: Land application (all effluent and 12 months/year) at location L7.
        - Spray Irrigation – Location L7 alone (capacity of 1.5 mgd) is not sufficient for this plant size.
        - Subsurface Drip – Location L7 alone (capacity of 2.3 mgd) is not sufficient for this plant size.

5.3 Satellite Facility Site Decision Matrix

Using the information presented for each satellite facility, a preliminary decision matrix of non-cost factors was prepared to further evaluate the list of potential satellite facility sites. This decision matrix includes consideration of several factors, including the following:

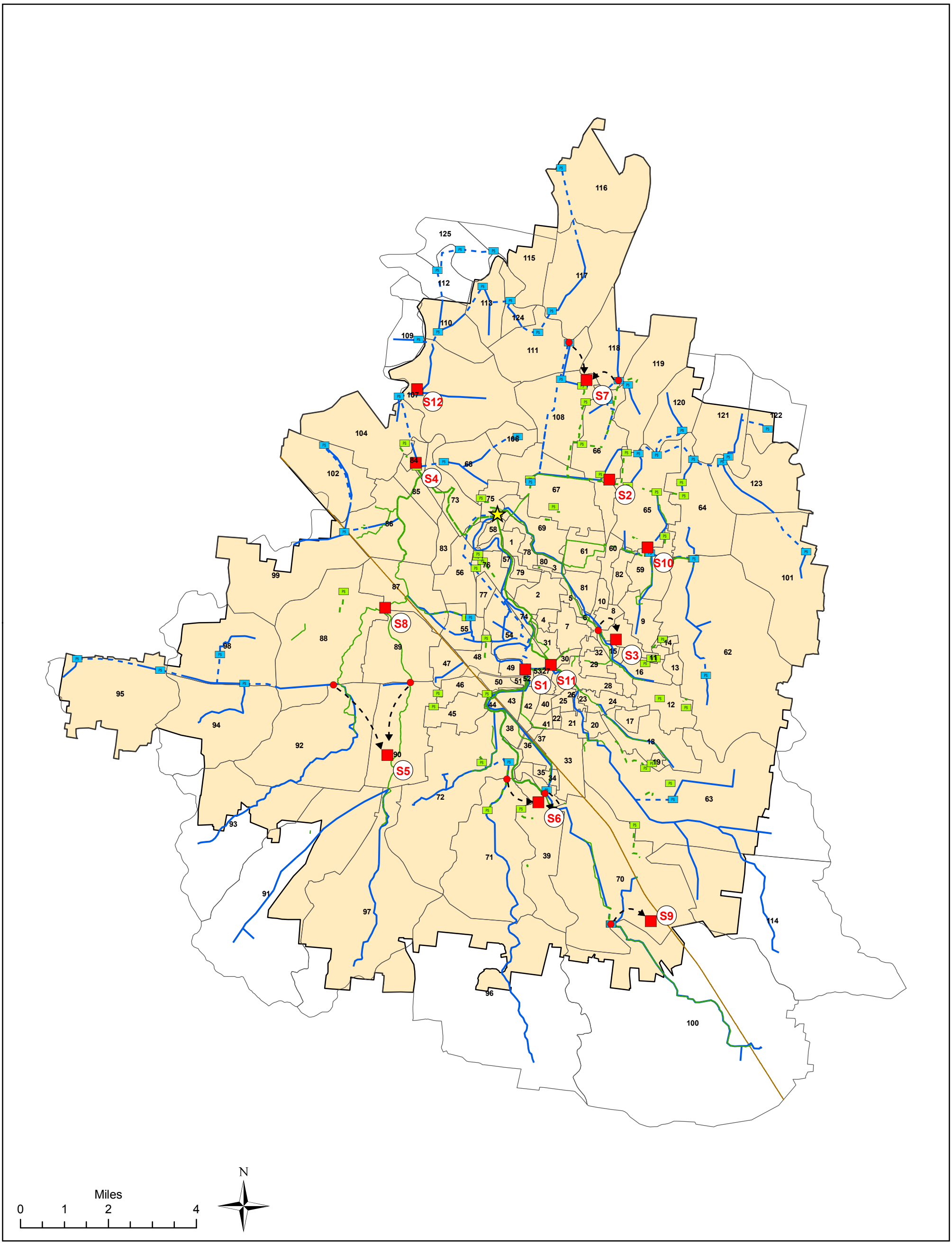
- Size of facility.
- Geographic area served by the facility.
- Effluent disposal options.
- Potential for public approval.
- Ability to relieve flow from Thompson Lane.
- Distance to Sinking Creek WWTP for biosolids treatment.
- Support of the repurification system.
- Near-term plant capacity requirements.

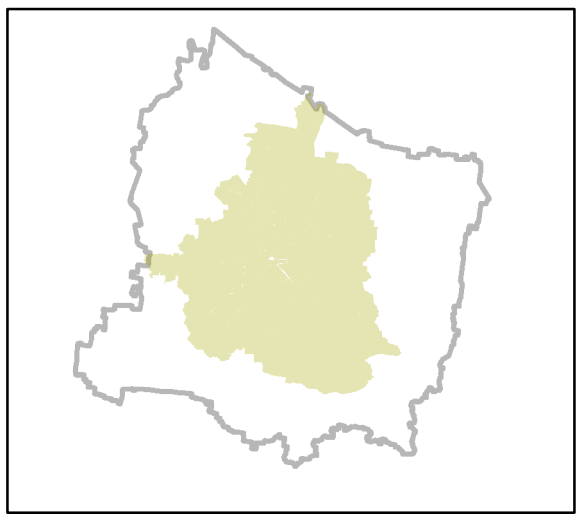
Each satellite facility was assigned a score for each of these previously mentioned non-cost factors. The scores were totaled and normalized with respect to the total score. Weighting values were also assigned to each of the decision factors to represent the importance of that factor to the overall objectives of the project. A weighted average was then calculated with respect to the value that was assigned to each non-cost criteria factor. For example, the size of the facility was assigned a 20 percent weight out of all eight factors. In contrast, the potential for public approval was assigned a 10 percent weight. Figure 5-4 provides the detailed decision matrix prepared for this evaluation. A summary of the weighted scores are provided in Table 5-2.

It is important to note that this ranking of potential satellite facility sites is based on attributes of individual sites. TM 7 will describe comprehensive solutions that will meet the overall objectives of the City in selecting a cost-effective collection and treatment system. Although several satellite facility options appear to be more/less favorable than others, many of these potential satellite facilities will be evaluated and incorporated in the final treatment and disposal alternatives in TM 7.

Table 5-2: Results of Preliminary Decision Matrix for Satellite Facilities

Rank	Satellite Facility Site No.	Weighted Average
1	S1	3.95
2	S11	3.75
3	S2	2.90
4	S4	2.90
5	S10	2.85
6	S3	2.65
7	S7	2.60
8	S6	2.55
9	S8	2.40
10	S5	2.25
11	S12	2.05
12	S9	2.00





Legend

- SCWWTP
- Pumped to Satellite Facilities
- Proposed Satellite Facility Sites (S#)
- 201 Pump Station
- Existing Pump Station
- Existing Force Main

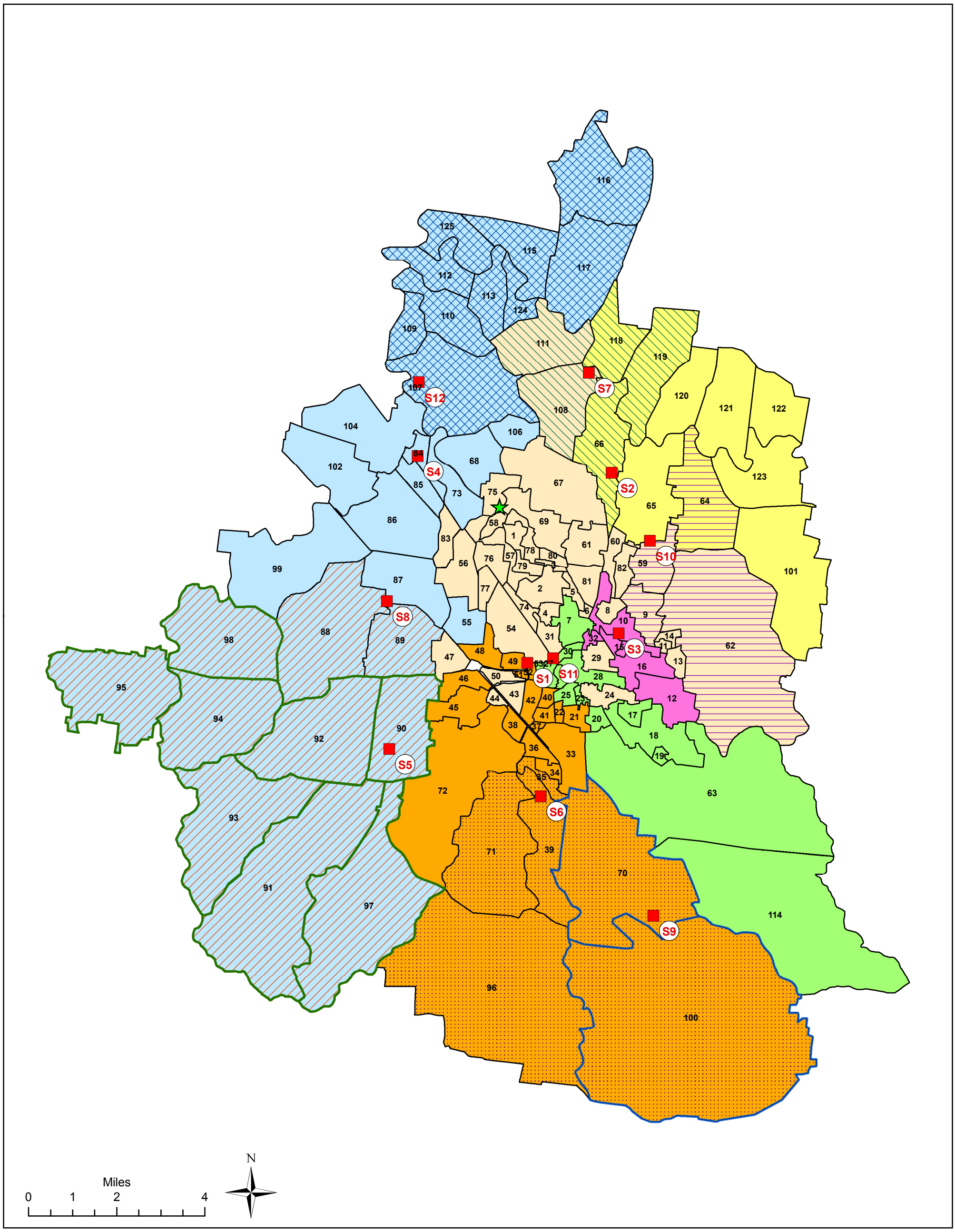
Existing Gravity Sewer

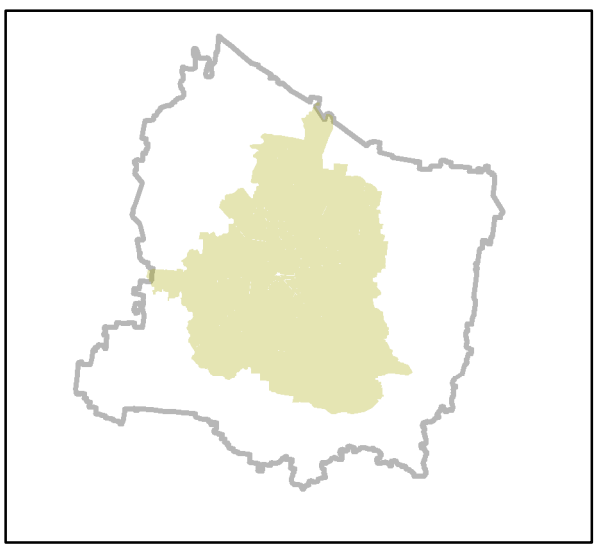
DIAMETER

- 16 - 27
- 28 - 54
- 201 Force Main
- 201 Gravity Sewer
- I-24
- Sewer Districts
- Murfreesboro Urban Growth Boundary

Figure 5-1
Proposed Satellite Facility Sites

Wastewater Treatment Capacity and
Effluent Disposal Study
Murfreesboro Water and Sewer Department





Legend

- SCWWTP
- Proposed Satellite Facility Sites (S#)
- S1 Districts
- S2 Districts
- S3 Districts
- S4 Districts
- S5 Districts
- S6 Districts
- S7 Districts
- S8 Districts
- S9 Districts
- S10 Districts
- S11 Districts
- S12 Districts
- Sewer Districts

Figure 5-2
Proposed Satellite Facility Service Areas

Wastewater Treatment Capacity and
Effluent Disposal Study
Murfreesboro Water and Sewer Department

Proposed Outfall #002

L7

L9, L10, L11

S12

S7

S4

S2

Existing Outfall #001

L8

S10

S8

S3

S1

S11

L1, L2, L3

S5

S6

L6

S9

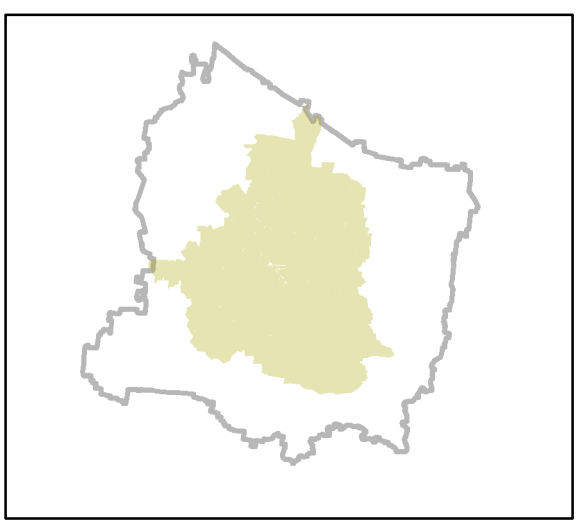
L4

L5

N

Miles

0 1 2 4



Legend

- SCWWTP
- Repurified Tank
- Roads
- Repurified Water Line
- Proposed Satellite Facility Sites (S#)
- Jordan Farm
- Coleman Farm
- Sewer Districts

Figure 5-3
Satellite Facility Sites and
Land Application Locations

Wastewater Treatment Capacity and
Effluent Disposal Study
Murfreesboro Water and Sewer Department

Figure 5-4: Evaluation of Satellite Facility Locations - Preliminary Decision Matrix

Wastewater Treatment Capacity and Effluent Disposal Study

For this preliminary decision round to narrow list of satellite facility locations, costs (capital and O&M) and treatment technologies (including expandability) are not considered.

Score:		
	1	Least Favorable
	5	Most Favorable

ID#	Options		A	B	C	D	E	F	G	H					
			Size of Facility	Areas Served by Facility	Effluent Disposal Options	Public Approval of Location	Sheds Flow from Thompson Ln OF Area	Meets short-term needs	Distance to SCWWTP for Biosolids Hauling	Supports Repurification System Initiatives	Total				
		Weight Factor (%):	20%	20%	15%	10%	15%	10%	5%	5%	100%	Average	Normalized	Weighted Average	Rank
	Satellite Facility														
S1	Satellite Facility Location No. 1	Notes:	See Criteria Below					See Criteria Below	See Criteria Below	Yes=4, No=2	30	3.75	5.00	3.95	1
		Score:	5	5	2	1	5	4	4	4					
S2	Satellite Facility Location No. 2	Notes:									24	3.00	4.00	2.90	3
		Score:	1	4	5	2	3	1	4	4					
S3	Satellite Facility Location No. 3	Notes:									23	2.88	3.83	2.65	6
		Score:	3	1	5	1	2	3	4	4					
S4	Satellite Facility Location No. 4	Notes:									22	2.75	3.67	2.90	4
		Score:	4	5	0	3	2	2	4	2					
S5	Satellite Facility Location No. 5	Notes:									18	2.25	3.00	2.25	10
		Score:	2	4	2	2	1	1	2	4					
S6	Satellite Facility Location No. 6	Notes:									20	2.50	3.33	2.55	8
		Score:	4	3	1	2	2	2	2	4					
S7	Satellite Facility Location No. 7	Notes:									23	2.88	3.83	2.60	7
		Score:	1	2	5	3	3	1	4	4					
S8	Satellite Facility Location No. 8	Notes:									19	2.38	3.17	2.40	9
		Score:	3	4	1	2	1	2	4	2					
S9	Satellite Facility Location No. 9	Notes:									16	2.00	2.67	2.00	12
		Score:	3	1	2	4	1	2	1	2					
S10	Satellite Facility Location No. 10	Notes:									24	3.00	4.00	2.85	5
		Score:	3	2	5	2	2	2	4	4					
S11	Satellite Facility Location No. 11	Notes:									29	3.63	4.83	3.75	2
		Score:	5	5	0	1	5	5	4	4					
S12	Satellite Facility Location No. 12	Notes:									18	2.25	3.00	2.05	11
		Score:	2	2	2	4	1	1	4	2					

Decision Criteria Ranges:

Item A:
Plant Size

MGD	Score
<2	1
2-4	2
4-6	3
6-8	4
>=8	5

Item F:
2010 Flow Rate (AADF)

MGD	Score
<1	1
1-2	2
2-3	3
3-6	4
>=6	5

SF	2010 AADF	Score
1	4.03	4
2	0.61	1
3	2.22	3
4	1.66	2
5	0.47	1
6	1.94	2
7	0.18	1
8	1.21	2
9	1.05	2
10	1.76	2
11	6.41	5
12	0.00	1

Item G:

Miles	Score
>8	1
6-8	2
4-6	3
2-4	4
< 2	5

SF	Miles	Score
1	3.5	4
2	2.6	4
3	3.9	4
4	2.0	4
5	6.0	2
6	6.6	2
7	3.5	4
8	3.2	4
9	9.9	1
10	3.4	4
11	3.6	4
12	3.1	4

Item H:
Yes = 4 No = 2

6. Centralized and Decentralized Capacity and Effluent Disposal Alternatives

6.1 Recommendations

The City of Murfreesboro is faced with several challenges for expanding and upgrading wastewater infrastructure. A growing population, an aging collection system, and environmental limitations on surface water discharges have complicated the planning process for the next capacity expansion. The projected wastewater flow in the year 2030 is estimated at 27 mgd annual average daily flow, 39.5 mgd maximum month, and a peak day flow of 85.2 mgd. The Sinking Creek WWTP is rated for a maximum month design flow of 16 mgd. Therefore, an additional 11 mgd of wastewater capacity (on an annual average day flow basis) will be needed for long-term growth in the service area.

The section provides a summary of the centralized and decentralized treatment alternatives for capacity expansion and effluent disposal. Both the centralized treatment and the decentralized treatment options have different associated collection system improvements. For example, the construction of satellite wastewater treatment facilities and the associated collection system improvements may defer or eliminate a larger collection system improvements cost associated with an expansion of the Sinking Creek WWTP. The identification of previously recommended collection system improvement projects that may be impacted by the construction of satellite facilities is discussed in TM 6.

Table 6-1 provides a matrix of eleven recommended treatment capacity expansion and effluent disposal alternatives. The land application capacity combinations were paired with the satellite treatment facility site locations (from Section 5.2). The satellite facility location rankings in Section 5.3 were used as a starting point for the alternatives matrix. Furthermore, these eleven recommendations 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 matrix of alternatives also includes a combination of centralized treatment expansion alternatives, such as a seasonal discharge to East Fork Stones River and an incremental increase in the surface water discharge to West Fork Stones River as a result of a re-rate analysis at the Sinking Creek WWTP. In Table 6-1, the eleven alternatives have been grouped by whether the proposed treatment expansion is within the Sinking Creek WWTP only, is a hybrid between expansion of the Sinking Creek WWTP and construction of satellite facility(ies), or is accomplished with satellite facilities only.

The land application effluent disposal capacity evaluations for each of the eleven alternatives assume subsurface drip disposal, with the exception of those options identified for continuing spray irrigation on Jordan and Coleman Farms. Subsurface drip irrigation reduces the total amount of acreage needed for effluent disposal (refer to TM 4). Therefore, the use of subsurface drip irrigation reduces capital cost. Additionally, 30 day wet weather storage is required for spray irrigation but not required for drip irrigation. Wet weather storage will significantly increase the capital cost of an effluent disposal option. 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 capacity, the spray/drip combination will be very similar to the capacity of drip disposal.

The estimated capital and O&M costs associated with each of the eleven alternatives are presented in TM 7, along with a review of non-cost factors. These eleven recommended treatment capacity and effluent disposal alternatives are used to develop a comprehensive list of solutions for the City.

6.2 Considerations for Technology Selection and Decentralized Facility Design

There are several treatment technologies that provide a wide and overlapping range of effluent quality, reliability, and operational ease. Specifically, six technologies were discussed in detail in TM 3 and each could be considered for use in a satellite facility. The issues to consider during the selection of a treatment technology for a particular application include the evaluation of the wastewater influent characteristics, the effluent limit specified in the permit, treatment reliability and redundancy, operability, energy efficiency, capital costs, operation and maintenance (O&M) costs, the potential for future regulatory action, and physical constraints (e.g., land availability and site location). Additionally, public perception may also play an important role in the design of a facility. For example, a treatment facility constructed on the fringe of development may be located in the center of a highly urbanized area in 15 years.

Another design consideration for the construction of decentralized treatment facilities is the decision to build either a stand-alone facility or a scalping facility. 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. Conversely, scalping facilities typically divert a fixed quantity of influent flow from an existing collection system location. The construction of a scalping facility 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. The decision to construct either type of facility will depend on the distance to the centralized treatment plant, the amount of land available, the potential for flow increases in the sewershed, the treatment performance and reliability at the centralized treatment facility, owner preference, capital costs, and operation and maintenance costs.

Table 6-1: Summary of Recommended Treatment Capacity and Effluent Disposal Alternatives for Future Capital Improvements Consideration

	Treatment		Effluent Disposal					
No. [1]	**Expand Sinking Creek WWTP**	**Construct Satellite Facility**	**Continuous Discharge to West Fork Stones**	**Continuous Discharge to East Fork Stones**	**Seasonal Discharge to East Fork Stones**	**Discharge to Cumberland River**	**Spray Irrigation**	**Subsurface Drip Disposal** [5]
Centralized Expansion Alternatives								
1	11 mgd				Yes [2]		1.0 mgd to Jordan Farm 1.8 mgd to Coleman Farm	2.9 mgd to L8 5.3 mgd to L9
8	11 mgd		Yes (4 mgd) [3]		Yes (7 mgd) [2]		1.0 mgd to Jordan Farm 1.8 mgd to Coleman Farm	2.9 mgd to L8 1.9 mgd to L7
9	11 mgd				Yes [2]	Yes [4]		
Centralized and Decentralized Alternatives								
5	8 mgd				Yes [2]		1.0 mgd to Jordan Farm 1.8 mgd to Coleman Farm	5.3 mgd to L9
		3 mgd at S8						2.1 mgd to L1 0.9 mgd to L3
6	8 mgd						1.0 mgd to Jordan Farm 1.8 mgd to Coleman Farm	5.3 mgd to L9
		5 mgd at S6						4.6 mgd to L4 0.4 mgd to L6
7	4 mgd		Yes (4 mgd) [3]					
		4 mgd at S4						2.3 mgd to L7 1.7 mgd to Jordan/Coleman
		5 mgd at S6						4.6 mgd to L4 0.4 mgd to L6

Table 6-1: Summary of Recommended Treatment Capacity and Effluent Disposal Alternatives for Future Capital Improvements Consideration

	Treatment		Effluent Disposal					
No. [1]	**Expand Sinking Creek WWTP**	**Construct Satellite Facility**	**Continuous Discharge to West Fork Stones**	**Continuous Discharge to East Fork Stones**	**Seasonal Discharge to East Fork Stones**	**Discharge to Cumberland River**	**Spray Irrigation**	**Subsurface Drip Disposal** [5]
10	4 mgd		Yes (4 mgd) [3]					
		9 mgd at S1						4.6 mgd to L4 3.1 mgd to L5 1.3 mgd to L2
11	4 mgd		Yes (4 mgd) [3]					
		9 mgd pump station at S1 then pump to S5; 1.5 mgd at S5						2.1 mgd to L1 1.3 mgd to L2 0.9 mgd to L3 4.6 mgd to L4
Decentralized Treatment Alternatives								
2		12 mgd at S11						4.6 mgd to L4 3.1 mgd to L5 2.2 mgd to L2 2.1 mgd to L1
3		9 mgd at S1			Yes [2]			4.6 mgd to L4 3.1 mgd to L5 1.3 mgd to L2
		3 mgd at S10					0.1 mgd to Coleman Farm	2.9 mgd to L8
4		9 mgd at S1						4.6 mgd to L4 3.1 mgd to L5 1.3 mgd to L2
		3 mgd at S8						2.1 mgd to L1 0.9 mgd to L3

Table 6-1: Summary of Recommended Treatment Capacity and Effluent Disposal Alternatives for Future Capital Improvements Consideration

	Treatment		Effluent Disposal					
No. [1]	Expand Sinking Creek WWTP	Construct Satellite Facility	Continuous Discharge to West Fork Stones	Continuous Discharge to East Fork Stones	Seasonal Discharge to East Fork Stones	Discharge to Cumberland River	Spray Irrigation	Subsurface Drip Disposal [5]

[1] The original numbering of alternatives was kept intact after sorting by centralized, hybrid (centralized / decentralized), and decentralized treatment alternatives.
[2] A seasonal discharge would be considered by TDEC for the colder months of November through April. Other effluent disposal options would be considered May through October.
[3] Request that TDEC consider a continuous 4 mgd capacity increase to West Fork Stones River to offset the capital and operation costs associated with land application effluent disposal and satellite wastewater treatment.
[4] A surface water discharge analysis to the Cumberland River was provided in TM 4 – Effluent Disposal Options.
[5] Subsurface drip irrigation reduces the total acreage required for effluent disposal, so capital costs are less than costs associated with spray irrigation. However, there are questions with respect to the reliability of subsurface drip disposal and the technology is maintenance intensive. Either subsurface drip disposal or spray irrigation may be used for any of these recommended alternatives.

7. References

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ATTACHMENT A

Summary of Influent Flow Data, Fiscal Years 2008, 2009, and 2010

July 2007 - June 2008	Influent Flow		Influent CBOD5			Influent Suspended Solids			Influent Ammonia Nitrogen			Influent Settleable Solids			Influent DO			Influent Temp	
		Monthly Avg		Monthly Avg	Monthly Avg		Monthly Avg	Monthly Avg		Monthly Avg	Monthly Avg		Monthly Avg	Monthly Avg		Monthly Avg	Monthly Avg		Monthly Avg
Month		mgd		mg/l	lb/d		mg/l	lb/d		mg/l	lb/d		mg/l	lb/d		mg/l	lb/d		°C
Jul-07		11.4		149	14,112		285	27,034		23.8	2,276		8.6	785		4.1	386		24.6
Aug-07		11.6		186	17,718		264	25,501		23.6	2,284		8.0	758		4.0	395		26.1
Sep-07		12.0		188	17,996		232	22,963		21.6	2,199		8.7	801		4.3	431		25.7
Oct-07		12.1		185	18,111		267	26,568		20.4	1,992		10.6	992		4.3	437		24.5
Nov-07		13.9		178	20,187		256	29,317		15.8	1,874		9.0	936		4.9	575		20.8
Dec-07		14.6		161	19,394		235	28,194		15.3	1,827		8.4	958		5.3	643		18.6
Jan-08		13.8		211	24,000		292	33,561		No Data	No Data		9.4	1,012		5.7	662		16.4
Feb-08		17.8		149	22,085		224	32,869		12.8	1,737		8.1	1,147		6.3	947		15.5
Mar-08		16.6		129	17,984		211	28,919		12.0	1,635		8.9	1,253		6.2	861		15.8
Apr-08		18.2		170	24,374		228	31,884		13.1	1,818		8.4	1,218		6.0	928		17.0
May-08		13.9		219	25,203		260	29,900		15.4	1,795		8.9	984		5.6	651		19.0
Jun-08		13.1		178	19,190		246	26,620		17.3	1,870		7.8	875		4.9	536		21.9
Average		14.1		175	20,030		250	28,611		17.4	1,937		8.7	976		5.1	621		20.5
Maximum Month		18.2		219	25,203		292	33,561		23.8	2,284		10.6	1,253		6	947		26.1
Minimum Month		11.4		129	14,112		211	22,963		12.0	1,635		7.8	758		4	386		15.5

Week	7 Day Avg	Monthly Avg	7 Day Avg	7 Day Avg	Monthly Avg	7 Day Avg	7 Day Avg	Monthly Avg	7 Day Avg	7 Day Avg	Monthly Avg	7 Day Avg	7 Day Avg	Monthly Avg	7 Day Avg	7 Day Avg	Monthly Avg	7 Day Avg	Monthly Avg
	mgd	mgd	mg/l	lb/d	lb/d	mg/l	lb/d	lb/d	mg/l	lb/d	lb/d	mg/l	lb/d	lb/d	mg/l	lb/d	lb/d	°C	°C
1	11.3		181	17,269		269	25,502		23.0	2,174		9.0	863		4.0	374		24.2	
2	11.2		212	19,800		295	27,613		24.0	2,288		7.5	663		4.1	387		24.5	
3	10.9		111	10,117		291	26,664		26.4	2,456		8.5	737		4.0	361		25.3	
4	11.6	11.4	108	10,356	14,112	294	28,389	27,034	22.4	2,176	2,276	8.0	667	785	4.1	399	386	24.4	24.6
5	11.9		135	13,347		264	26,467		21.2	2,146		10.0	992		4.4	435		25.0	
6	11.2		200	18,584		263	24,538		21.0	1,989		9.5	872		3.9	366		25.7	
7	10.5		247	21,659		293	25,766		24.4	2,169		7.0	584		3.7	320		26.6	
8	12.2	11.6	175	17,681	17,718	261	26,189	25,501	24.0	2,316	2,284	8.0	714	758	4.2	436	395	26.2	26.1
9	12.5		151	15,438		228	24,019		26.8	2,810		7.5	863		4.1	427		26.5	
10	11.1		254	23,464		278	26,012		28.6	2,706		9.0	773		4.0	367		26.5	
11	13.8		120	12,747		194	22,183		18.5	2,223		9.0	818		4.1	477		26.0	
12	12.1	12.0	137	13,814	17,996	232	23,488	22,963	17.8	1,815	2,199	10.0	1,059	801	4.7	474	431	25.0	25.7
13	11.2		225	21,002		237	22,106		21.5	2,052		8.5	751		4.6	433		25.2	
14	10.8		248	22,222		259	23,290		22.7	2,047		7.0	601		4.0	360		25.7	
15	10.7		158	14,059		267	23,759		26.0	2,329		15.0	1,376		4.2	372		25.4	
16	10.8	12.1	182	16,339	18,111	287	25,905	26,568	20.2	1,842	1,992	9.0	766	992	4.5	402	437	24.7	24.5
17	15.1		140	16,737		247	30,538		13.4	1,718		10.5	911		4.6	576		23.5	
18	12.9		233	24,928		262	28,129		17.4	1,881		8.0	914		4.5	483		22.3	
19	13.6		133	14,544		273	30,817		15.1	1,757		10.0	959		4.7	539		21.3	
20	13.3	13.9	182	20,109	20,187	270	29,726	29,317	15.7	1,764	1,874	9.5	959	936	4.7	522	575	20.8	20.8
21	13.4		216	23,894		266	29,472		16.6	1,866		7.5	813		5.1	564		20.2	
22	15.8		148	19,323		201	26,718		15.9	2,205		9.0	1,013		5.2	696		20.1	
23	13.3		162	17,979		252	27,985		16.8	1,878		10.0	1,109		4.8	531		18.9	
24	14.9	14.6	178	22,069	19,394	252	30,518	28,194	15.3	1,907	1,827	7.5	808	958	4.8	600	643	19.1	18.6
25	15.0		162	20,303		241	29,995		13.1	1,638		8.0	1,061		5.1	646		18.6	
26	14.6		144	17,381		216	26,063		16.0	1,885		8.0	854		6.2	755		18.1	
27	14.8		177	21,678		213	26,265		No Data	No Data		No Data	No Data		6.3	779		16.9	
28	13.5	13.8	219	24,777	24,000	315	35,589	33,561	No Data	No Data	No Data	10.0	1,109	1,012	5.7	640	662	17.1	16.4
29	13.2		233	25,517		313	34,423		No Data	No Data		8.0	881		5.6	618		16.7	
30	13.3		203	22,400		247	27,506		No Data	No Data		9.5	1,006		5.7	629		15.9	
31	17.6		175	23,822		313	42,498		No Data	No Data		10.0	1,051		5.9	876		15.5	
32	20.0	17.8	127	21,115	22,085	197	33,038	32,869	No Data	No Data	1,737	7.0	1,115	1,147	6.9	1,154	947	15.4	15.5
33	18.3		150	23,714		183	28,529		10.1	1,551		8.5	1,191		6.5	999		15.4	
34	16.2		197	26,938		233	31,767		13.8	1,856		8.0	1,148		5.6	756		15.7	
35	15.0		127	15,855		282	35,018		14.6	1,803		9.0	1,133		6.1	765		15.8	
36	17.1	16.6	186	26,445	17,984	217	30,639	28,919	12.5	1,777	1,635	11.0	1,367	1,253	6.5	936	861	15.7	15.8
37	17.3		117	16,812		211	30,284		12.3	1,705		7.0	1,121		6.0	875		15.5	
38	17.3		105	15,267		196	28,589		10.9	1,570		7.5	1,170		6.1	878		16.0	
39	14.3		117	13,950		240	28,468		12.4	1,451		10.0	1,209		6.3	747		16.1	
40	24.7	18.2	124	25,331	24,374	146	29,200	31,884	8.7	1,735	1,818	9.0	1,396	1,218	6.6	1,378	928	16.0	17.0
41	21.4		154	26,652		183	30,935		9.2	1,552		6.5	1,545		6.4	1,131		16.3	
42	15.6		161	20,882		264	34,214		14.7	1,891		9.0	1,254		6.1	795		16.9	
43	13.9		182	21,013		284	32,857		17.7	2,058		10.0	1,193		5.2	605		17.8	
44	13.5	13.9	249	27,932	25,203	273	30,674	29,900	15.4	1,743	1,795	8.0	882	984	5.1	580	651	18.7	19.0
45	13.4		245	27,267		276	30,911		15.6	1,723		7.5	826		5.7	640		18.9	
46	14.8		162	19,929		245	30,240		12.3	1,534		9.0	1,088		6.1	754		18.3	
47	13.2		251	27,334		291	31,981		18.4	2,003		9.0	1,037		5.2	575		18.8	
48	14.6	13.1	201	24,635	19,190	217	25,783	26,620	15.9	2,081	1,870	10.0	984	875	5.4	664	536	20.1	21.9
49	15.1		147	18,534		228	28,629		14.0	1,793		8.0	1,088		5.5	696		21.2	
50	13.0		171	18,556		258	27,952		17.1	1,853		8.5	872		4.9	535		21.2	
51	12.4		188	19,400		232	23,975		17.4	1,802		7.0	759		4.8	499		21.7	
52	11.5		207	19,894		266	25,593		21.7	2,118		7.5	701		4.4	424		22.4	

	Influent Flow		Influent CBOD5			Influent Suspended Solids			Influent Ammonia Nitrogen			Influent Settleable Solids			Influent DO			Influent Temp
July 2008 - June 2009		**Monthly Avg**		**Monthly Avg**	**Monthly Avg**		**Monthly Avg**	**Monthly Avg**		**Monthly Avg**	**Monthly Avg**		**Monthly Avg**	**Monthly Avg**		**Monthly Avg**	**Monthly Avg**		**Monthly Avg**
Month		**mgd**		**mg/l**	**lb/d**		**mg/l**	**lb/d**		**mg/l**	**lb/d**		**mg/l**	**lb/d**		**mg/l**	**lb/d**		**°C**
Jul-08		11.4		198	18,716		286	27,191		18.0	1,723		7.3	675		4.8	455		24.0
Aug-08		11.0		276	25,048		327	29,882		21.3	1,956		8.8	755		4.7	429		25.4
Sep-08		10.9		310	28,100		385	35,126		21.1	1,943		8.4	728		4.3	393		25.1
Oct-08		11.3		294	27,477		406	38,118		22.4	2,124		6.8	604		3.9	369		23.6
Nov-08		11.3		296	27,993		367	35,055		20.8	1,987		9.5	876		4.2	396		20.2
Dec-08		17.8		237	33,219		338	47,941		12.5	1,653		6.9	985		5.2	788		17.3
Jan-09		16.8		239	32,147		289	39,109		11.6	1,602		7.4	930		6.2	877		15.6
Feb-09		14.6		305	36,861		357	43,048		14.8	1,786		7.4	882		6.7	811		14.9
Mar-09		20.3		223	37,298		298	50,377		10.0	1,560		5.6	1,012		6.9	1,182		14.9
Apr-09		19.8		227	35,909		328	48,801		9.7	1,486		5.9	983		6.5	1,082		16.2
May-09		22.0		207	34,943		336	56,626		8.9	1,470		7.0	1,260		5.7	1,061		17.8
Jun-09		13.6		252	28,031		401	44,864		15.7	1,754		6.5	697		4.5	510		21.7
Average		15.0		255	30,479		343	41,345		15.6	1,754		7.3	866		5.3	696		19.7
Maximum Month		22.0		310	37,298		406	56,626		22.4	2,124		9.5	1,260		6.9	1,182		25.4
Minimum Month		10.9		198	18,716		286	27,191		8.9	1,470		5.6	604		3.9	369		14.9

	7 Day Avg	Monthly Avg	7 Day Avg	7 Day Avg	Monthly Avg	7 Day Avg	7 Day Avg	Monthly Avg	7 Day Avg	7 Day Avg	Monthly Avg	7 Day Avg	7 Day Avg	Monthly Avg	7 Day Avg	7 Day Avg	Monthly Avg	7 Day Avg	Monthly Avg
Week	**mgd**	**mgd**	**mg/l**	**lb/d**	**lb/d**	**mg/l**	**lb/d**	**lb/d**	**mg/l**	**lb/d**	**lb/d**	**mg/l**	**lb/d**	**lb/d**	**mg/l**	**lb/d**	**lb/d**	**°C**	**°C**
1	11.6		196	18,909		251	24,363		14.7	1,454		6.5	602		4.6	440		22.2	
2	11.5		191	18,335		281	26,891		18.4	1,774		9.0	856		5.0	475		23.8	
3	10.8		250	22,556		284	25,751		17.6	1,624		6.5	558		5.1	461		24.8	
4	11.6	11.4	150	14,456	18,716	309	29,602	27,191	20.5	1,965	1,723	7.0	683	675	4.6	448	455	24.7	24.0
5	11.0		268	24,403		309	28,466		19.6	1,837		8.5	723		4.6	423		25.2	
6	10.4		249	21,650		330	28,876		23.6	2,089		7.5	619		4.8	414		25.6	
7	10.1		268	22,606		376	31,804		21.4	1,826		8.5	702		4.8	405		25.3	
8	10.4	11.0	323	28,102	25,048	353	31,243	29,882	22.4	1,973	1,956	12.0	1,031	755	4.3	374	429	25.8	25.4
9	13.1		251	27,124		278	30,706		17.3	1,912		7.5	701		5.0	544		25.0	
10	11.6		298	28,694		354	34,293		20.3	2,004		8.0	727		4.7	452		25.2	
11	10.8		295	26,627		381	34,539		20.2	1,845		8.5	737		4.5	402		25.0	
12	10.6	10.9	331	29,366	28,100	424	37,769	35,126	21.6	1,951	1,943	9.0	773	728	4.2	375	393	25.1	25.1
13	10.4		312	27,120		368	32,325		22.8	2,012		8.0	674		3.9	343		25.1	
14	10.3		318	27,445		409	35,575		24.5	2,161		7.0	572		3.9	336		24.8	
15	11.7		299	29,037		395	38,789		24.1	2,388		7.5	669		4.0	386		24.2	
16	11.0	11.3	303	27,835	27,477	454	41,935	38,118	19.9	1,862	2,124	6.5	569	604	3.8	348	369	23.9	23.6
17	11.7		272	26,336		359	34,416		22.7	2,177		6.0	605		3.9	381		22.9	
18	11.3		283	26,711		373	35,583		20.4	1,973		6.0	535		4.0	381		21.9	
19	11.2		275	25,690		351	32,857		24.7	2,325		15.0	1,364		4.1	384		21.4	
20	11.8	11.3	278	27,416	27,993	311	30,727	35,055	20.1	1,965	1,987	9.0	901	876	4.1	400	396	20.7	20.2
21	11.7		312	30,516		431	42,411		19.9	1,984		8.5	787		4.1	403		19.0	
22	10.8		328	29,760		445	41,473		19.4	1,793		9.0	796		4.5	402		18.7	
23	12.0		312	31,173		417	41,582		20.6	2,075		8.0	794		4.3	426		18.3	
24	22.9	17.8	192	34,913	33,219	295	54,752	47,941	9.8	1,625	1,653	6.0	976	985	5.1	969	788	17.6	17.3
25	18.7		223	34,755		319	50,265		7.9	1,253		7.0	1,080		5.5	860		17.0	
26	18.3		210	31,772		275	41,598		10.1	1,531		6.5	1,090		6.1	934		16.2	
27	15.8		234	30,753		298	39,791		10.9	1,480		6.0	731		5.8	763		16.3	
28	21.7	16.8	161	28,484	32,147	202	35,707	39,109	9.1	1,641	1,602	8.0	1,334	930	6.4	1,144	877	16.1	15.6
29	16.0		261	34,892		307	41,685		11.5	1,560		7.5	882		6.2	827		15.3	
30	13.0		295	32,214		377	41,509		15.2	1,678		8.0	774		6.3	687		15.4	
31	17.7		243	35,294		267	39,332		11.2	1,661		7.5	1,020		6.7	993		14.7	
32	14.5	14.6	285	34,475	36,861	343	41,705	43,048	13.1	1,612	1,786	6.5	726	882	6.8	818	811	14.4	14.9
33	14.2		304	35,909		374	44,345		14.8	1,758		8.5	971		6.6	780		15.3	
34	14.2		325	38,643		362	42,942		16.6	1,982		7.0	811		6.4	760		14.8	
35	17.2		292	39,372		343	45,493		14.9	1,915		6.5	1,220		7.2	1,064		15.0	
36	17.9	20.3	256	38,266	37,298	300	45,241	50,377	9.4	1,449	1,560	6.0	791	1,012	6.6	997	1,182	14.6	14.9
37	20.4		209	32,651		279	41,767		14.7	2,027		5.5	1,330		6.8	1,161		15.1	
38	18.3		206	31,624		287	44,972		7.6	1,175		5.0	651		7.0	1,076		15.1	
39	23.7		226	45,271		333	69,092		8.6	1,527		5.0	1,068		7.0	1,387		15.1	
40	26.0	19.8	212	43,700	35,909	294	60,431	48,801	7.5	1,438	1,486	6.0	1,401	983	7.0	1,524	1,082	15.3	16.2
41	19.8		200	33,188		324	39,239		9.7	1,538		4.0	674		6.7	1,095		15.6	
42	19.4		213	34,886		281	46,560		7.9	1,327		6.5	981		6.7	1,093		16.0	
43	16.3		247	33,691		348	47,672		11.2	1,543		7.0	876		5.7	779		17.1	
44	24.0	22.0	211	34,700	34,943	349	56,213	56,626	11.6	1,660	1,470	5.0	1,480	1,260	6.1	1,218	1,061	17.5	17.8
45	30.4		148	37,425		232	58,846		5.7	1,424		7.5	1,902		5.9	1,486		17.3	
46	20.3		214	36,443		345	59,315		8.2	1,393		7.5	1,188		5.9	1,002		17.7	
47	15.7		249	32,774		391	52,103		9.5	1,277		8.0	941		5.4	712		18.3	
48	15.2	13.6	262	33,529	28,031	459	58,979	44,864	13.6	1,772	1,754	7.0	788	697	5.1	655	510	18.8	21.7
49	13.8		311	36,045		444	51,424		16.0	1,866		6.5	688		4.7	545		20.0	
50	15.5		189	23,356		353	42,960		14.2	1,706		6.0	776		4.9	629		21.4	
51	13.4		200	22,268		340	38,294		14.5	1,645		6.5	678		4.5	502		22.8	
52	11.9		295	29,447		431	43,413		17.5	1,766		7.0	648		3.9	385		22.7	

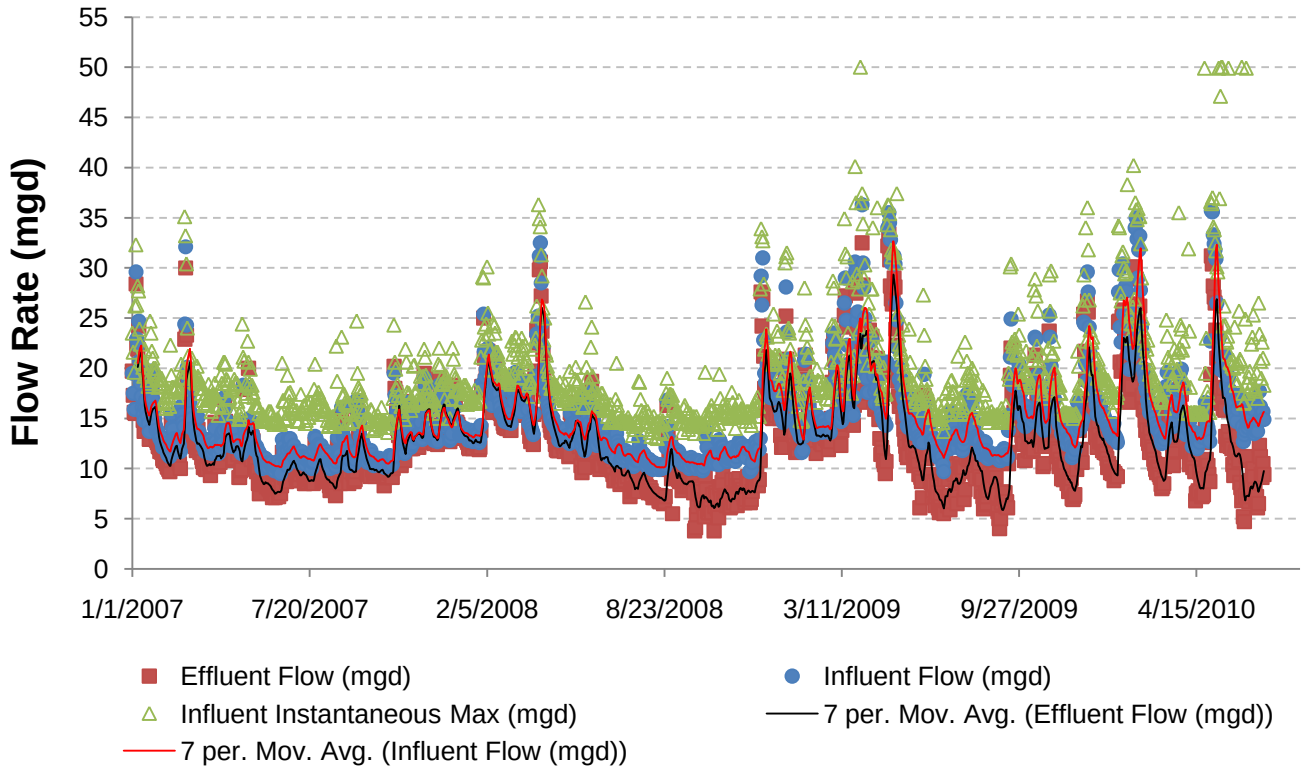
July 2009- June 2010	Influent Flow		Influent CBOD5			Influent Suspended Solids			Influent Ammonia Nitrogen			Influent Settleable Solids			Influent DO			Influent Temp	
		Monthly Avg		Monthly Avg	Monthly Avg		Monthly Avg	Monthly Avg		Monthly Avg	Monthly Avg		Monthly Avg	Monthly Avg		Monthly Avg	Monthly Avg		Monthly Avg
Month		mgd		mg/l	lb/d		mg/l	lb/d		mg/l	lb/d		mg/l	lb/d		mg/l	lb/d		°C
Jul-09		13.1		278	30,579		392	43,376		16.1	1,798		6.8	703		4.4	479		23.5
Aug-09		12.6		244	25,310		291	30,714		21.9	2,289		6.6	681		4.2	442		23.9
Sep-09		15.2		233	27,614		261	31,648		16.8	1,939		6.8	817		4.4	569		23.4
Oct-09		16.3		210	27,971		254	33,774		12.6	1,678		6.3	793		5.3	719		20.8
Nov-09		14.6		221	26,263		271	32,340		15.8	1,894		6.8	845		5.3	649		18.9
Dec-09		18.2		160	24,167		178	27,137		10.8	1,552		5.8	926		6.3	970		16.5
Jan-10		19.3		180	26,844		175	26,409		12.9	1,801		5.5	929		6.4	1,044		14.8
Feb-10		21.9		123	21,166		142	24,226		8.9	1,547		6.4	1,074		6.9	1,274		13.7
Mar-10		15.9		176	22,703		183	23,440		13.2	1,698		6.1	825		6.4	858		14.5
Apr-10		13.8		178	20,437		218	24,972		17.7	2,007		6.6	791		4.9	570		17.8
May-10		21.9		146	25,867		162	28,702		10.4	1,719		5.9	1,095		5.7	1,054		19.8
Jun-10		15.1		175	21,902		211	25,575		16.8	2,101		6.5	782		4.7	598		22.4
Average		16.5		194	25,069		228	29,360		14.5	1,835		6.3	855		5.4	769		19.2
Maximum Month		21.9		278	30,579		392	43,376		21.9	2,289		6.8	1,095		6.9	1,274		23.9
Minimum Month		12.6		123	20,437		142	23,440		8.9	1,547		5.5	681		4.2	442		13.7

	7 Day Avg	Monthly Avg	7 Day Avg	7 Day Avg	Monthly Avg	7 Day Avg	7 Day Avg	Monthly Avg	7 Day Avg	7 Day Avg	Monthly Avg	7 Day Avg	7 Day Avg	Monthly Avg	7 Day Avg	7 Day Avg	Monthly Avg	7 Day Avg	Monthly Avg
Week	mgd	mgd	mg/l	lb/d	lb/d	mg/l	lb/d	lb/d	mg/l	lb/d	lb/d	mg/l	lb/d	lb/d	mg/l	lb/d	lb/d	°C	°C
1	11.8		259	25,680		381	38,369		16.6	1,664		7.5	801		4.4	428		23.0	
2	13.4		290	32,359		373	41,742		13.8	1,568		8.0	834		4.3	478		23.9	
3	13.2		299	33,176		422	47,063		16.8	1,894		5.5	555		4.9	537		23.2	
4	12.9	13.1	284	30,767	30,579	411	44,937	43,376	19.9	2,195	1,798	6.0	620	703	4.1	438	479	23.4	23.5
5	15.4		217	27,917		301	38,819		13.4	1,729		7.0	899		4.0	513		23.6	
6	14.0		216	25,210		314	37,057		15.5	1,824		5.5	592		4.3	502		23.5	
7	12.1		251	25,271		292	29,578		24.7	2,551		7.0	666		4.0	402		24.0	
8	11.7	12.6	253	24,704	25,310	287	28,365	30,714	24.7	2,473	2,289	6.5	596	681	4.6	455	442	24.2	23.9
9	11.3		276	26,037		281	26,571		25.9	2,443		7.0	654		4.1	387		24.6	
10	11.2		299	27,859		296	27,725		22.1	2,088		8.5	766		4.1	382		23.8	
11	11.8		293	28,930		307	30,559		22.5	2,255		7.0	642		4.1	402		24.2	
12	19.4	15.2	180	28,671	27,614	233	36,833	31,648	11.2	1,781	1,939	5.5	839	817	4.8	785	569	23.2	23.4
13	18.6		167	25,856		204	31,389		10.5	1,589		6.0	1,021		4.7	726		22.4	
14	15.2		198	24,792		239	30,527		13.1	1,703		6.0	711		4.9	624		21.1	
15	15.1		237	29,751		304	38,295		13.1	1,661		7.0	858		5.2	654		21.3	
16	19.3	16.3	185	29,518	27,971	233	36,607	33,774	10.2	1,643	1,678	6.0	911	793	5.4	876	719	20.7	20.8
17	14.5		223	27,092		258	31,448		14.0	1,724		6.0	691		5.6	676		20.7	
18	19.2		169	25,541		191	28,860		11.6	1,637		5.5	1,060		5.6	901		19.8	
19	16.3		211	28,720		261	35,821		14.6	2,025		6.5	819		5.5	750		19.5	
20	14.1	14.6	214	25,064	26,263	265	31,076	32,340	17.1	2,035	1,894	7.5	844	845	5.2	609	649	19.2	18.9
21	13.1		249	27,365		354	38,811		17.4	1,923		7.0	759		4.8	523		18.7	
22	12.3		244	24,830		251	25,930		16.4	1,691		7.5	744		5.0	515		17.7	
23	14.9		177	22,061		205	25,579		14.2	1,796		7.0	835		5.8	717		17.7	
24	24.2	18.2	148	30,623	24,167	187	39,094	27,137	6.2	1,249	1,552	5.5	1,358	926	6.4	1,306	970	16.8	16.5
25	19.1		144	22,714		150	23,618		10.5	1,670		5.0	776		7.0	1,121		15.7	
26	16.2		163	21,949		161	21,607		10.4	1,403		5.5	734		7.0	943		16.0	
27	14.9		196	24,288		167	20,749		13.3	1,658		6.5	791		5.4	672		15.4	
28	13.6	19.3	219	24,956	26,844	211	24,003	26,409	17.4	1,992	1,801	6.0	666	929	6.3	711	1,044	14.9	14.8
29	19.1		201	29,283		199	28,392		16.4	2,114		5.0	1,243		6.4	1,048		14.3	
30	26.8		128	28,074		130	28,851		6.2	1,397		4.5	957		6.7	1,500		15.0	
31	21.9		145	26,474		160	29,297		9.8	1,787		5.5	991		6.4	1,166		14.3	
32	30.3	21.9	104	26,702	21,166	127	31,350	24,226	6.6	1,563	1,547	6.0	1,646	1,074	7.1	1,815	1,274	13.9	13.7
33	23.6		86	16,422		83	15,603		8.4	1,624		6.0	976		7.0	1,392		13.4	
34	16.8		153	21,409		187	26,248		10.1	1,440		7.0	911		6.7	941		13.7	
35	14.8		151	18,615		179	22,067		12.2	1,515		6.5	764		6.7	828		13.7	
36	13.2	15.9	205	22,407	22,703	218	23,956	23,440	15.6	1,733	1,698	7.0	730	825	6.2	678	858	14.3	14.5
37	16.6		190	25,903		187	25,036		13.1	1,705		6.5	970		6.3	874		14.9	
38	15.6		195	25,285		192	24,879		13.7	1,830		5.0	617		6.4	840		15.1	
39	18.3		126	18,767		134	19,965		10.4	1,543		6.0	981		6.9	1,048		14.1	
40	14.8	13.8	154	18,997	20,437	175	21,464	24,972	12.8	1,594	2,007	7.0	841	791	5.7	709	570	16.0	17.8
41	13.6		179	20,239		213	24,116		16.6	1,926		7.0	753		4.8	545		17.6	
42	12.9		182	19,651		242	26,039		20.4	2,169		6.0	671		4.3	464		18.2	
43	14.6		181	22,172		234	28,170		19.6	2,270		6.5	900		5.0	608		18.7	
44	24.0	21.9	162	28,743	25,867	177	30,945	28,702	11.5	1,432	1,719	3.0	893	1,095	5.8	1,195	1,054	18.6	19.8
45	27.0		146	31,637		174	37,439		7.5	1,637		6.0	1,136		5.6	1,282		18.3	
46	20.4		128	21,808		151	25,911		10.8	1,838		7.0	1,243		6.1	1,037		19.4	
47	17.8		142	20,917		143	21,079		12.5	1,825		7.5	1,107		5.5	817		20.9	
48	16.2	15.1	180	24,479	21,902	193	26,175	25,575	15.4	2,155	2,101	No Data	No Data	782	5.2	700	598	21.7	22.4
49	15.4		190	24,331		219	27,943		15.4	1,915		6.5	770		5.4	702		22.1	
50	14.7		180	21,946		229	23,943		17.7	2,172		6.5	786		4.6	561		22.0	
51	14.6		185	22,414		200	24,149		19.6	2,426		7.0	806		4.4	539		22.5	
52	15.5		152	19,419		202	25,858		15.4	1,936		6.0	766		4.4	570		23.2	

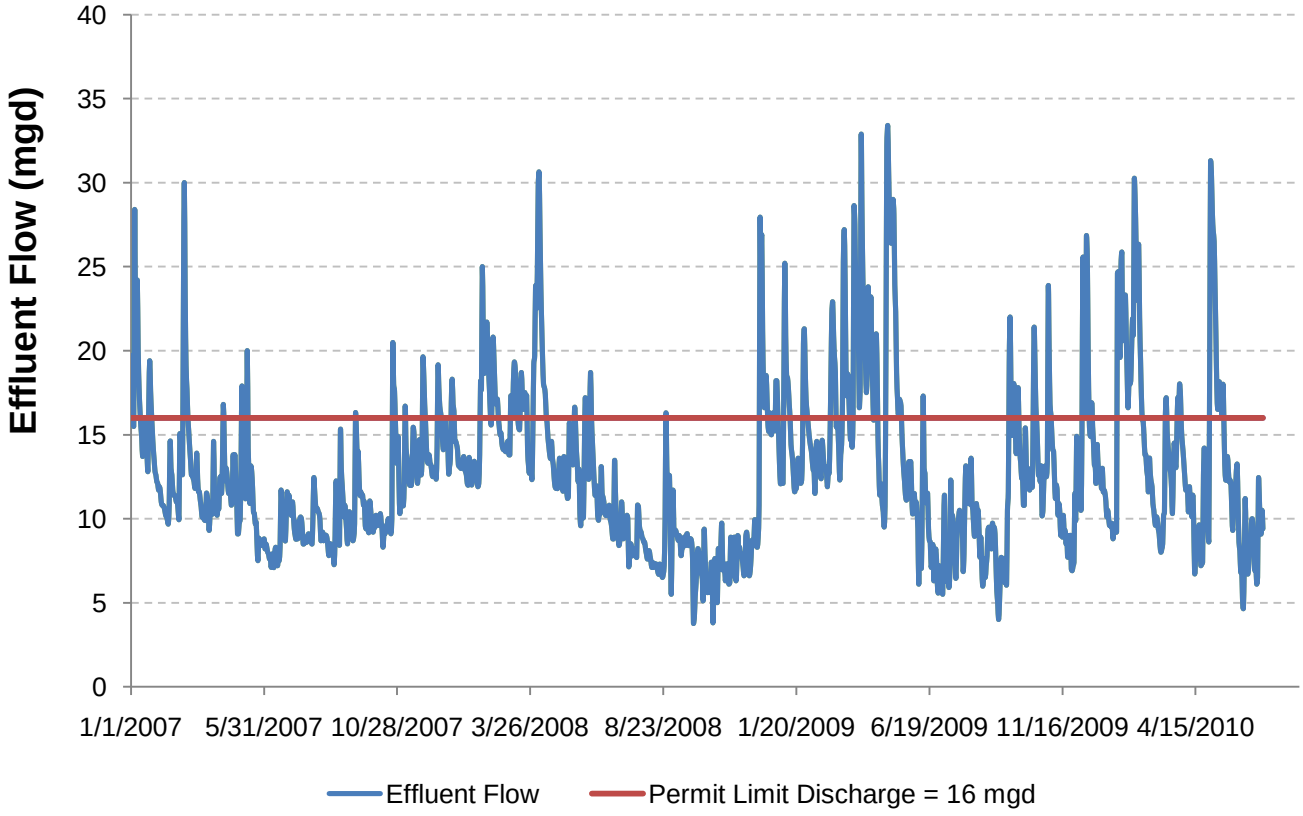
ATTACHMENT B

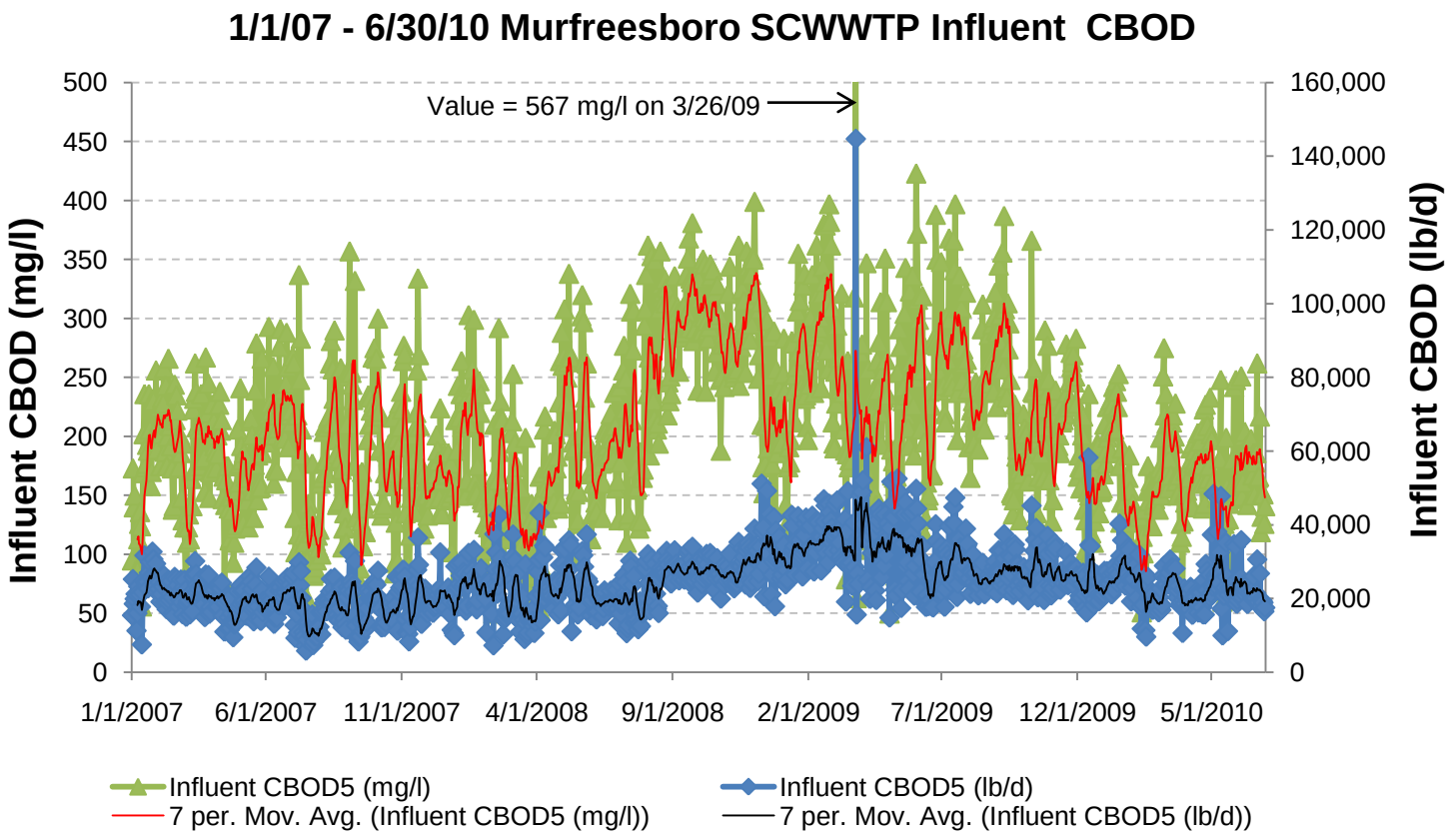
Graphical Illustration of Influent and Effluent Characterization

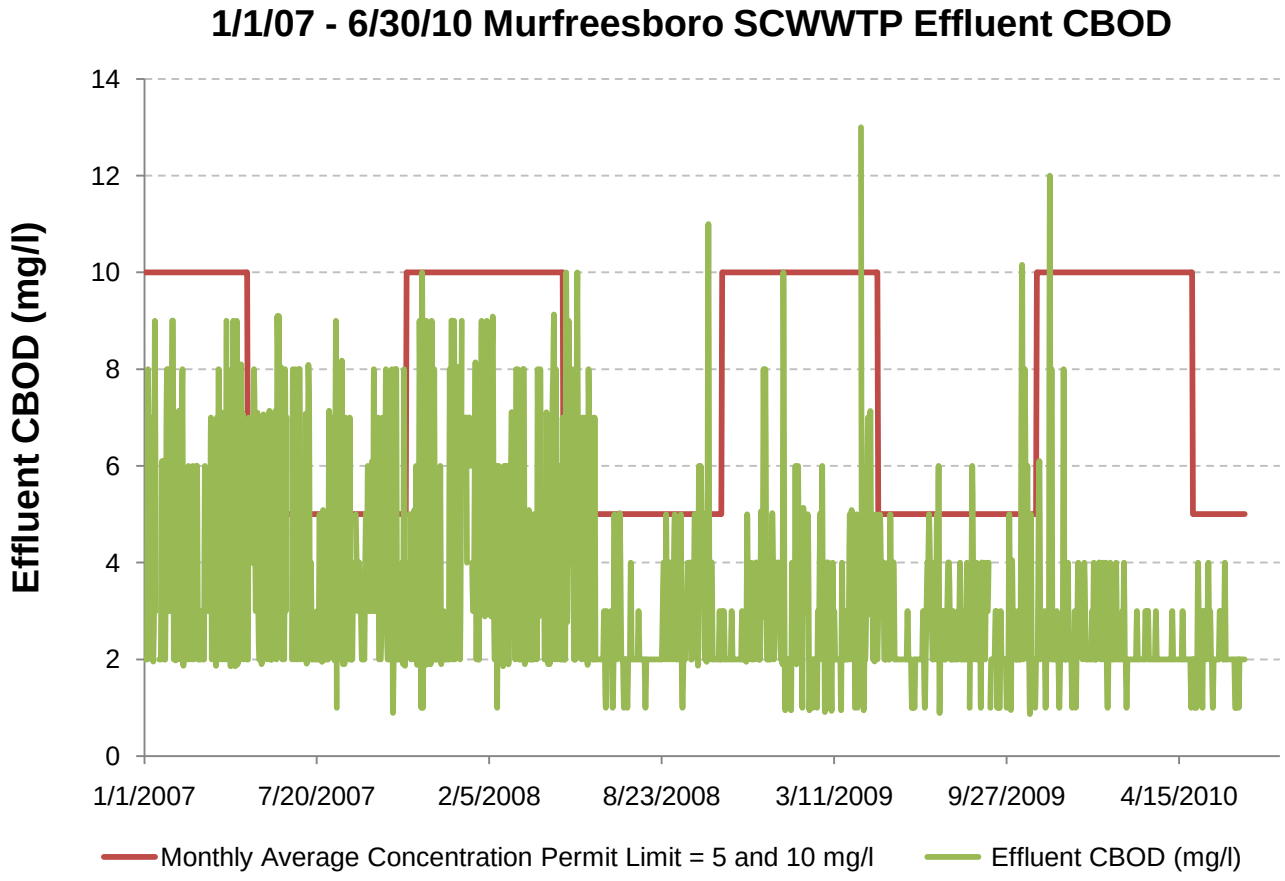
1/1/07 - 6/30/10 Murfreesboro SCWWTP Influent and Effluent Flow Rate

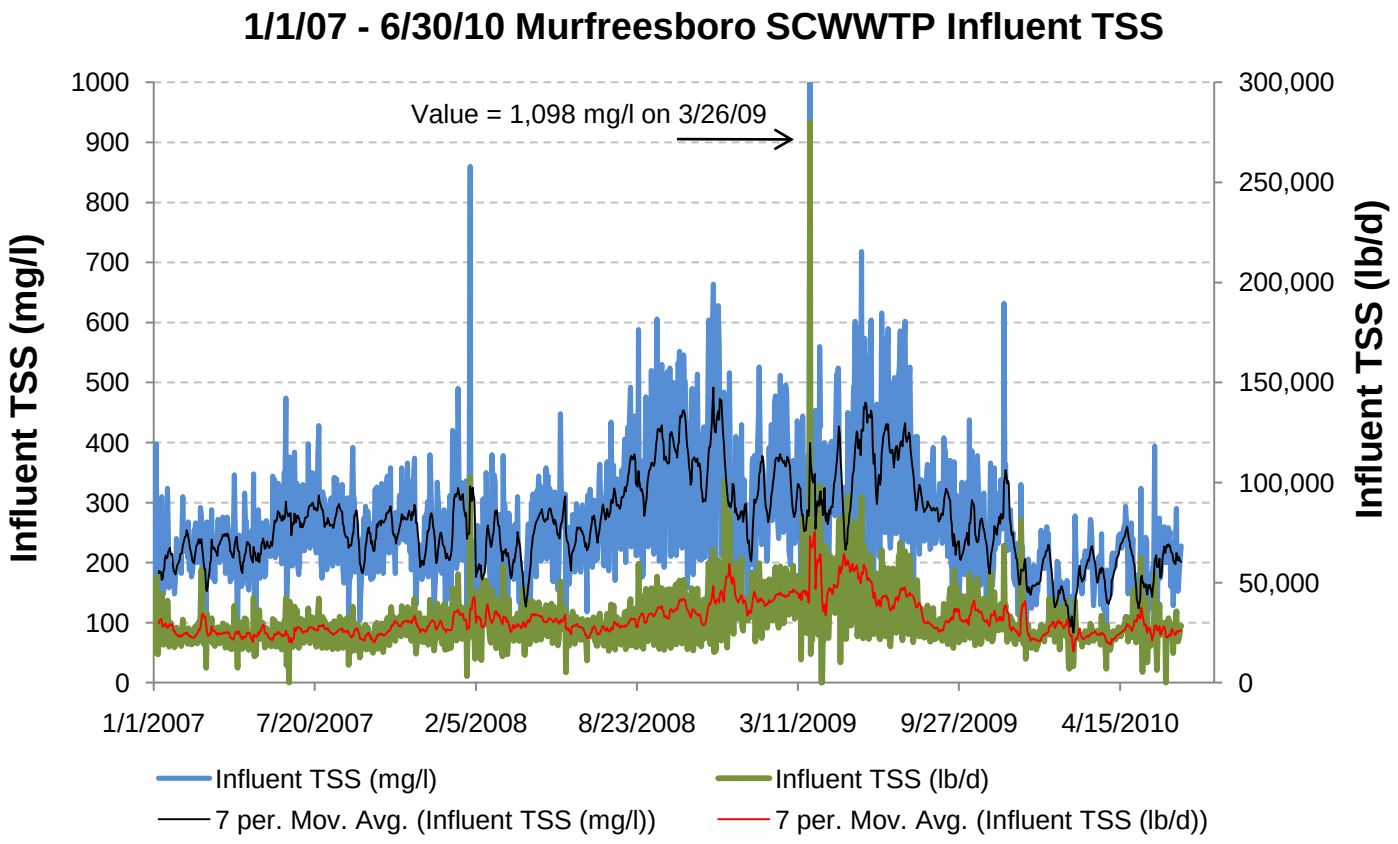


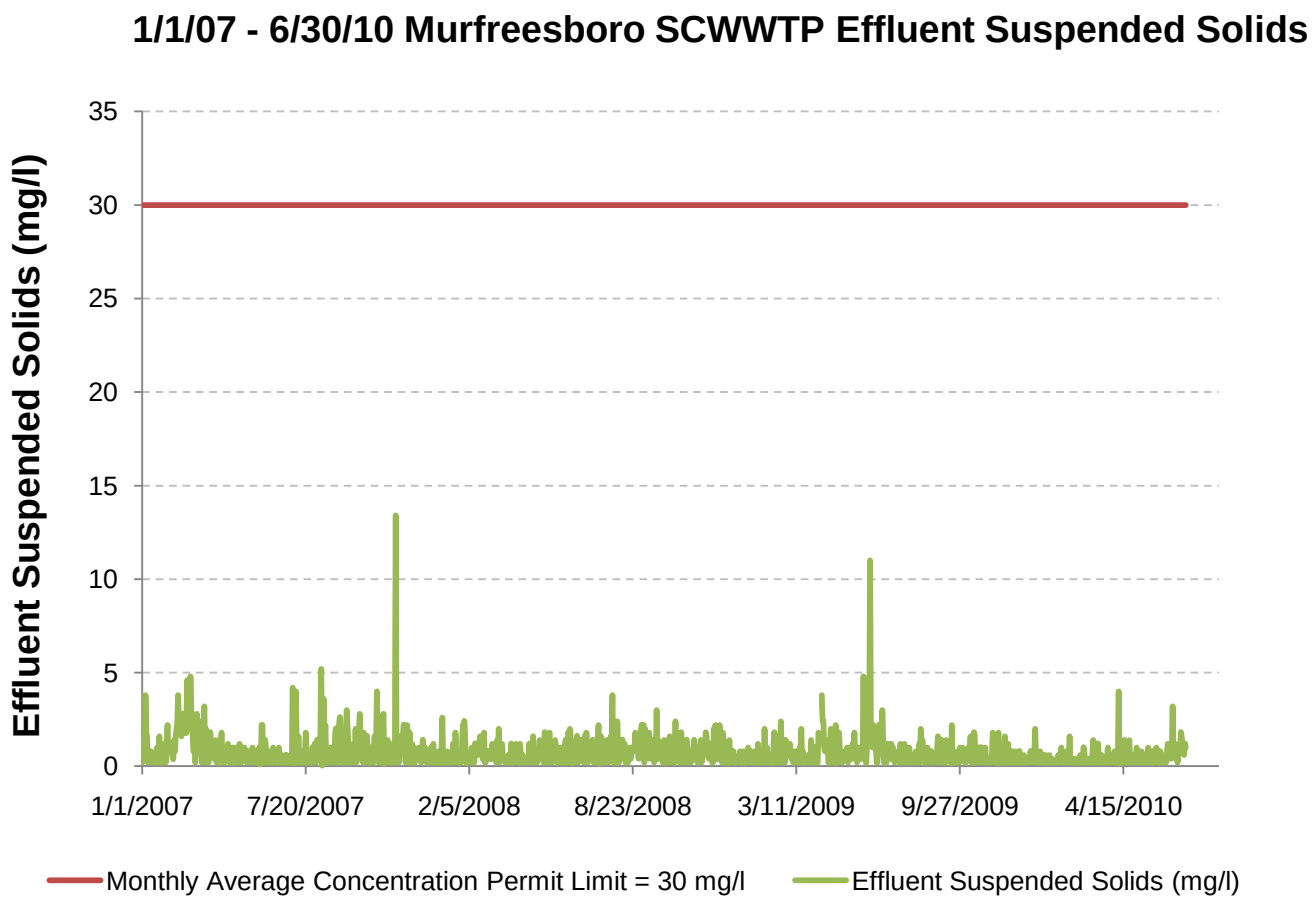
1/1/07 - 6/30/10 Murfreesboro SCWWTP Effluent Flow



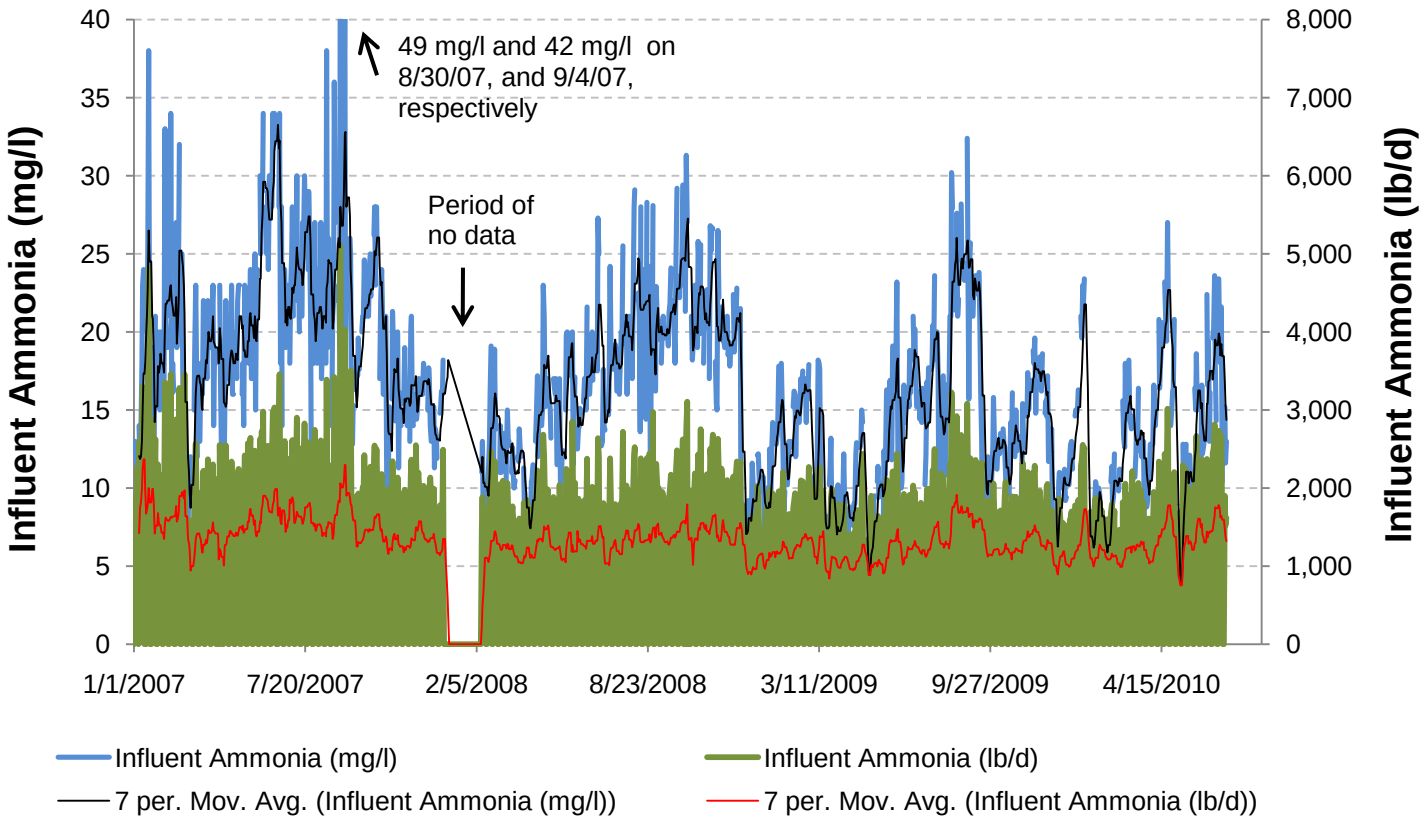

1/1/07 - 6/30/10 Murfreesboro SCWWTP Influent CBOD
Value = 567 mg/l on 3/26/09
Influent CBOD (mg/l)
Influent CBOD (lb/d)
500
450
400
350
300
250
200
150
100
50
0
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1/1/2007
6/1/2007
11/1/2007
4/1/2008
9/1/2008
2/1/2009
7/1/2009
12/1/2009
5/1/2010
Influent CBOD5 (mg/l)
Influent CBOD5 (lb/d)
7 per. Mov. Avg. (Influent CBOD5 (mg/l))
7 per. Mov. Avg. (Influent CBOD5 (lb/d))


1/1/07 - 6/30/10 Murfreesboro SCWWTP Effluent CBOD
Effluent CBOD (mg/l)
14
12
10
8
6
4
2
0
1/1/2007
7/20/2007
2/5/2008
8/23/2008
3/11/2009
9/27/2009
4/15/2010
Monthly Average Concentration Permit Limit = 5 and 10 mg/l
Effluent CBOD (mg/l)

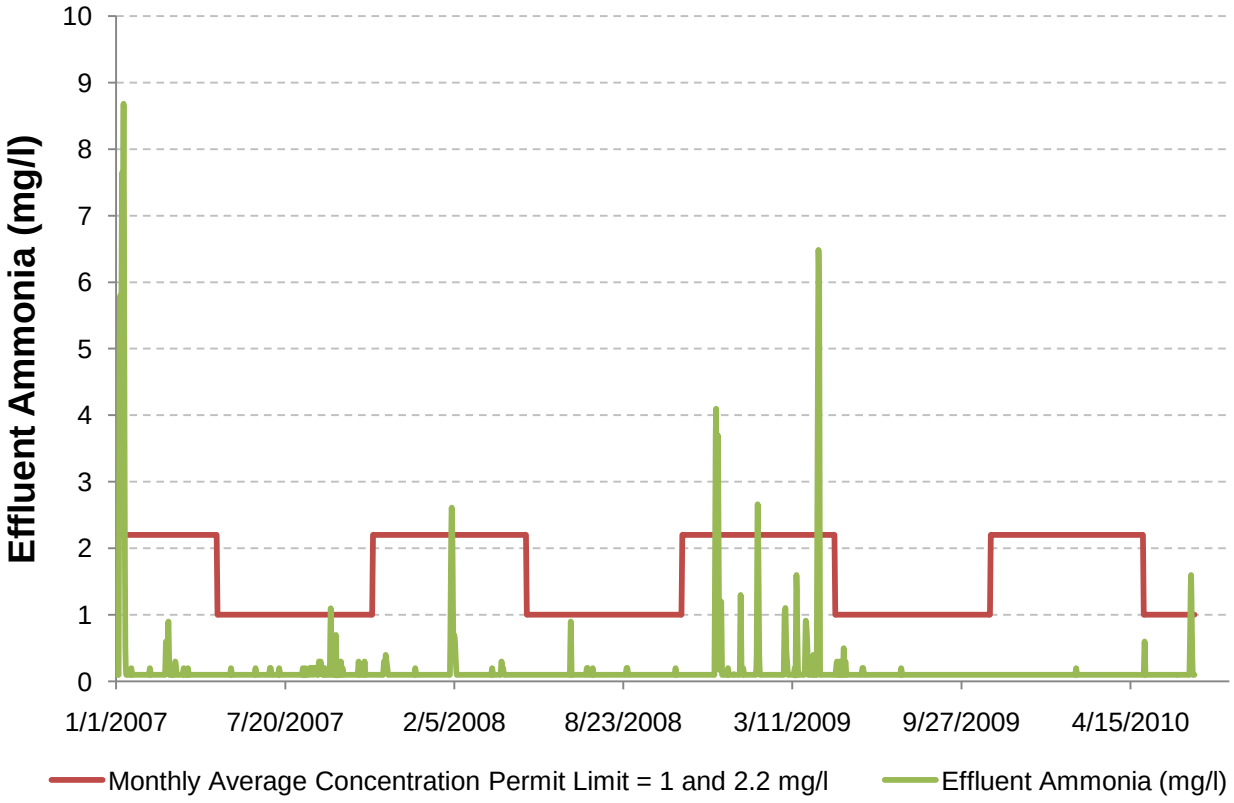

1/1/07 - 6/30/10 Murfreesboro SCWWTP Influent TSS
Value = 1,098 mg/l on 3/26/09
Influent TSS (mg/l)
Influent TSS (lb/d)
1000
900
800
700
600
500
400
300
200
100
0
300,000
250,000
200,000
150,000
100,000
50,000
0
1/1/2007
7/20/2007
2/5/2008
8/23/2008
3/11/2009
9/27/2009
4/15/2010
Influent TSS (mg/l)
Influent TSS (lb/d)
7 per. Mov. Avg. (Influent TSS (mg/l))
7 per. Mov. Avg. (Influent TSS (lb/d))


1/1/07 - 6/30/10 Murfreesboro SCWWTP Effluent Suspended Solids
Effluent Suspended Solids (mg/l)
35
30
25
20
15
10
5
0
1/1/2007
7/20/2007
2/5/2008
8/23/2008
3/11/2009
9/27/2009
4/15/2010
Monthly Average Concentration Permit Limit = 30 mg/l
Effluent Suspended Solids (mg/l)

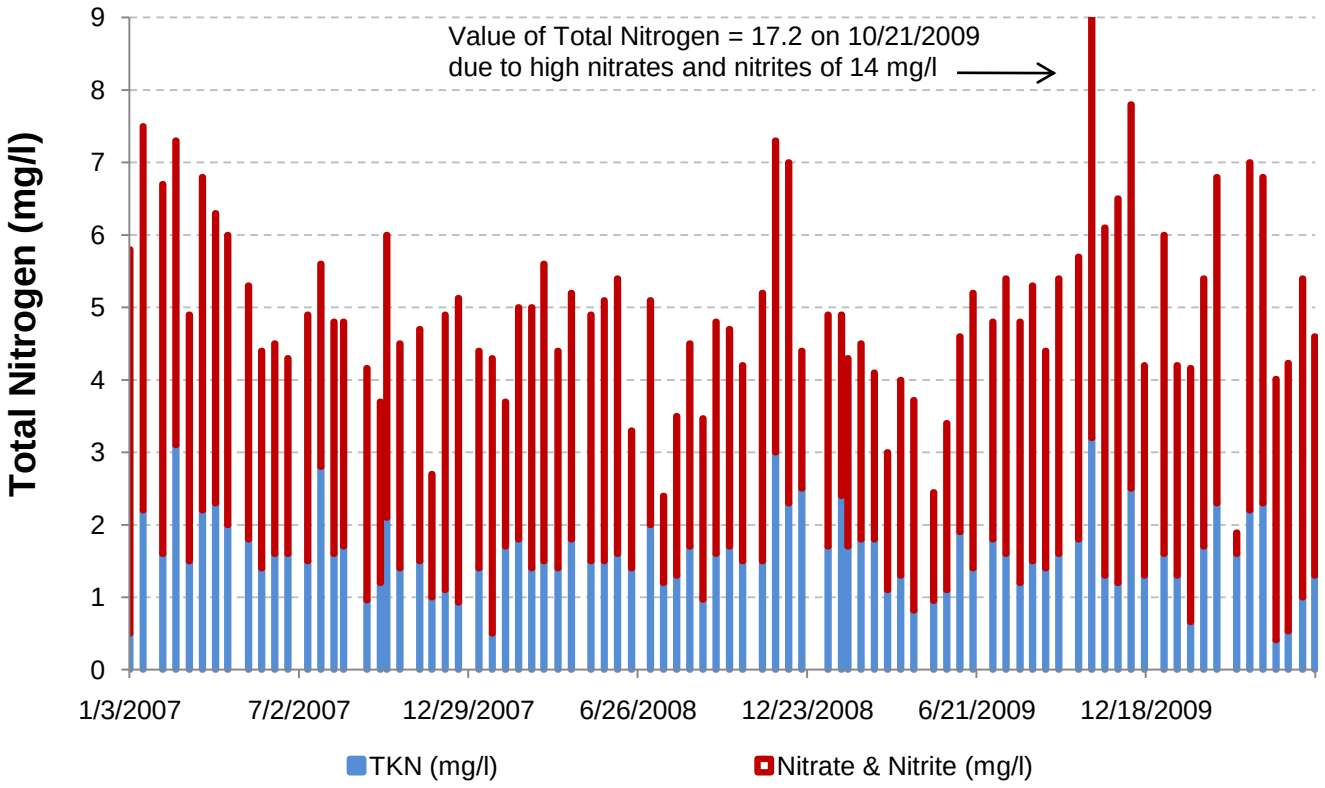
1/1/07 - 6/30/10 Murfreesboro SCWWTP Influent Ammonia



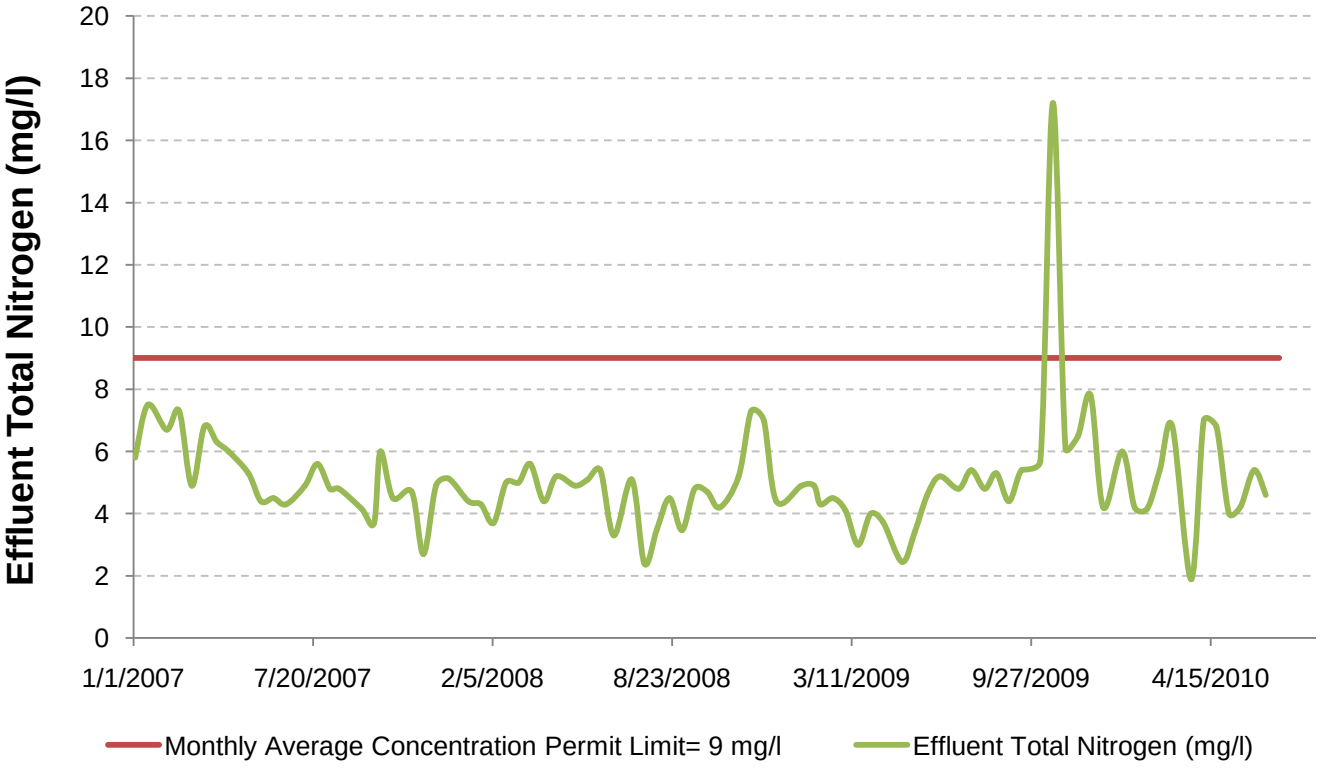
1/1/07 - 6/30/10 Murfreesboro SCWWTP Effluent Ammonia



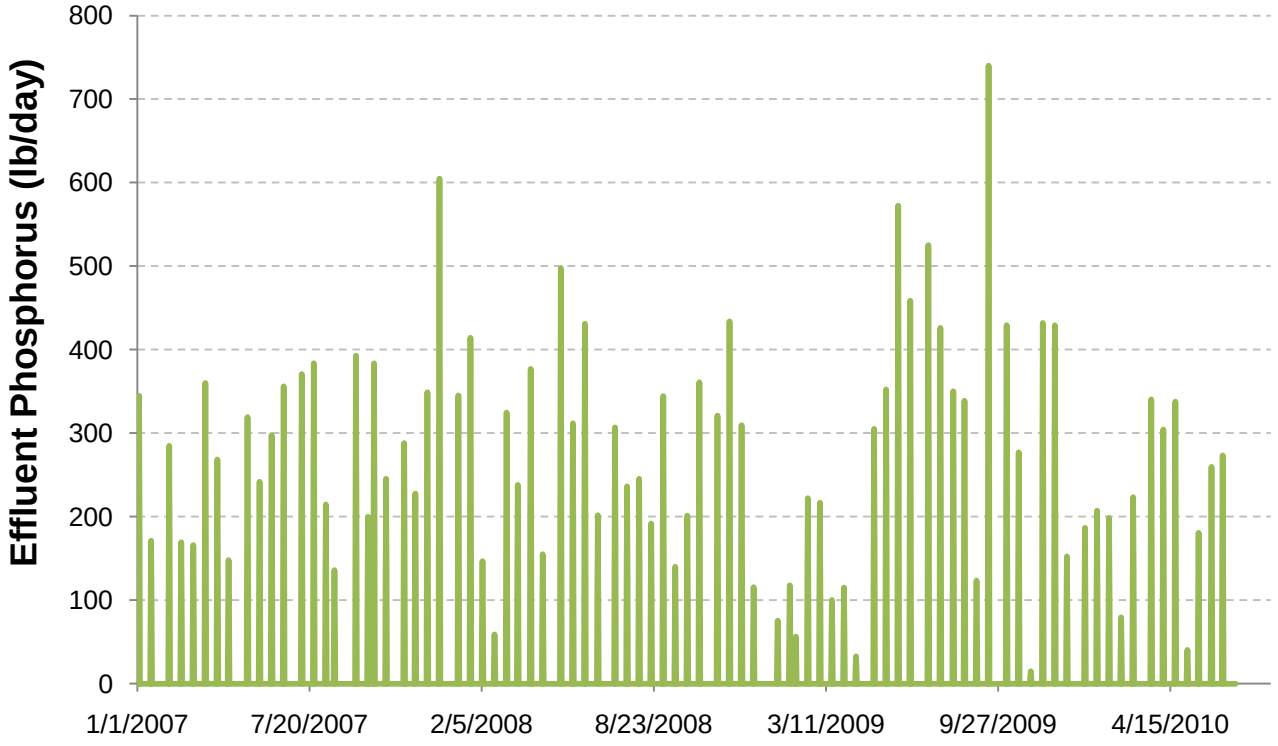
1/1/07 - 6/30/10 SCWWTP Nitrogen Constituents in Final Effluent



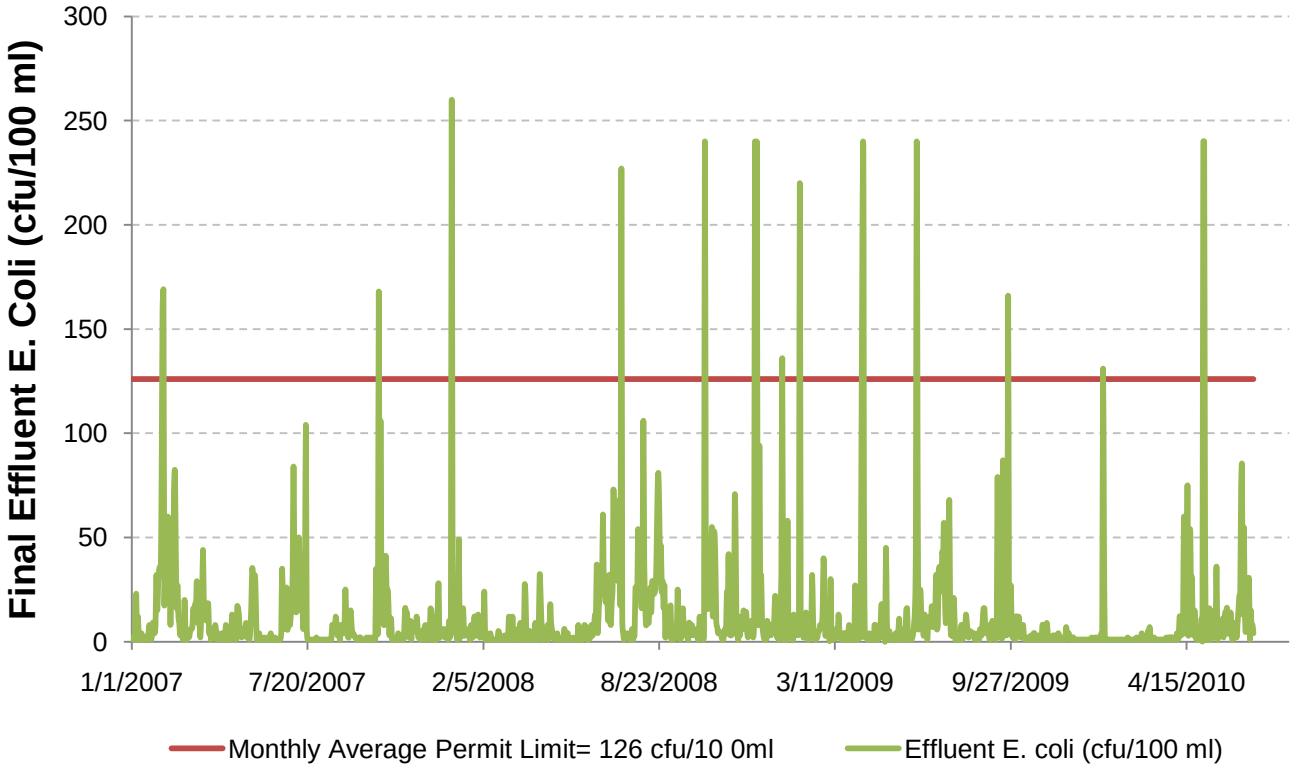
1/1/07 - 6/30/10 Murfreesboro SCWWTP Effluent Total Nitrogen

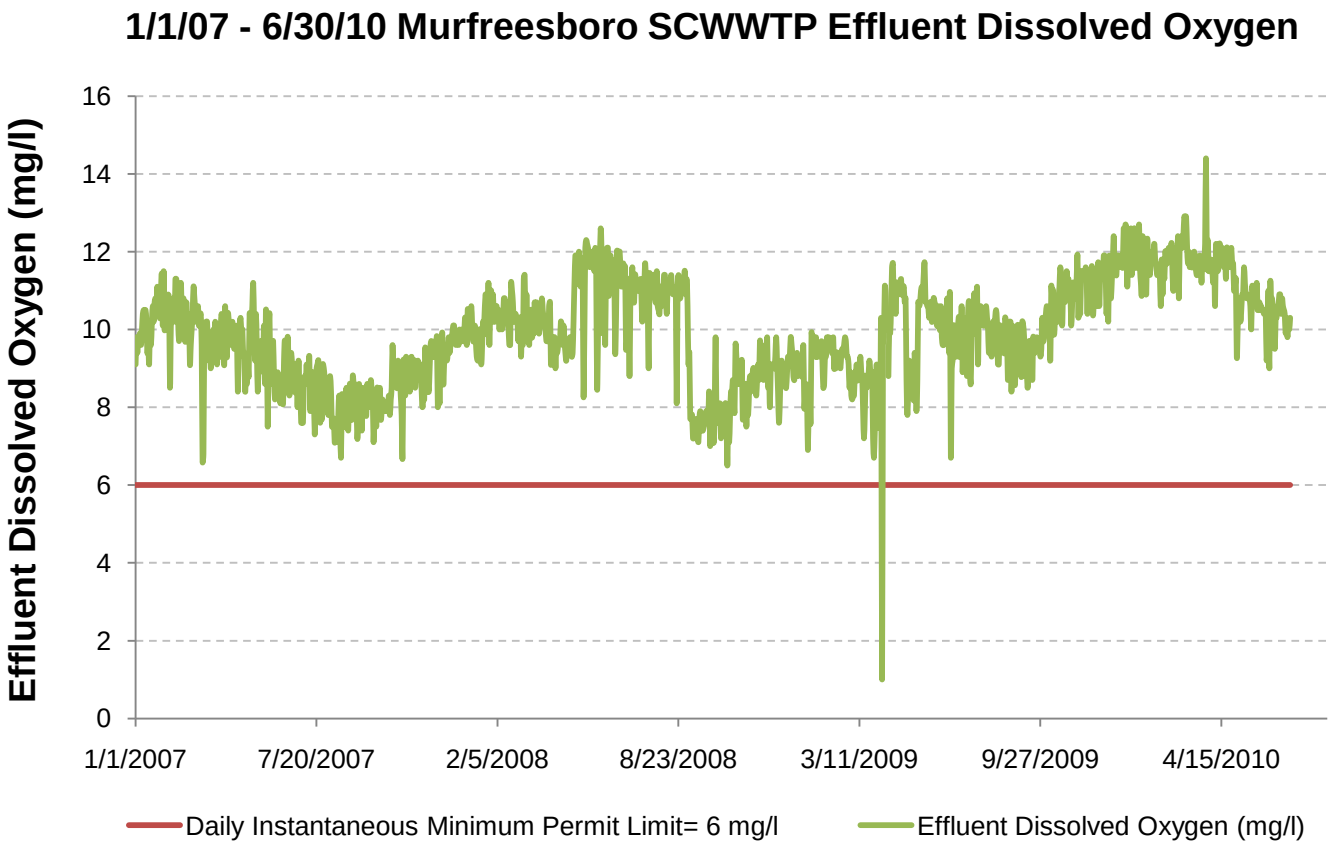


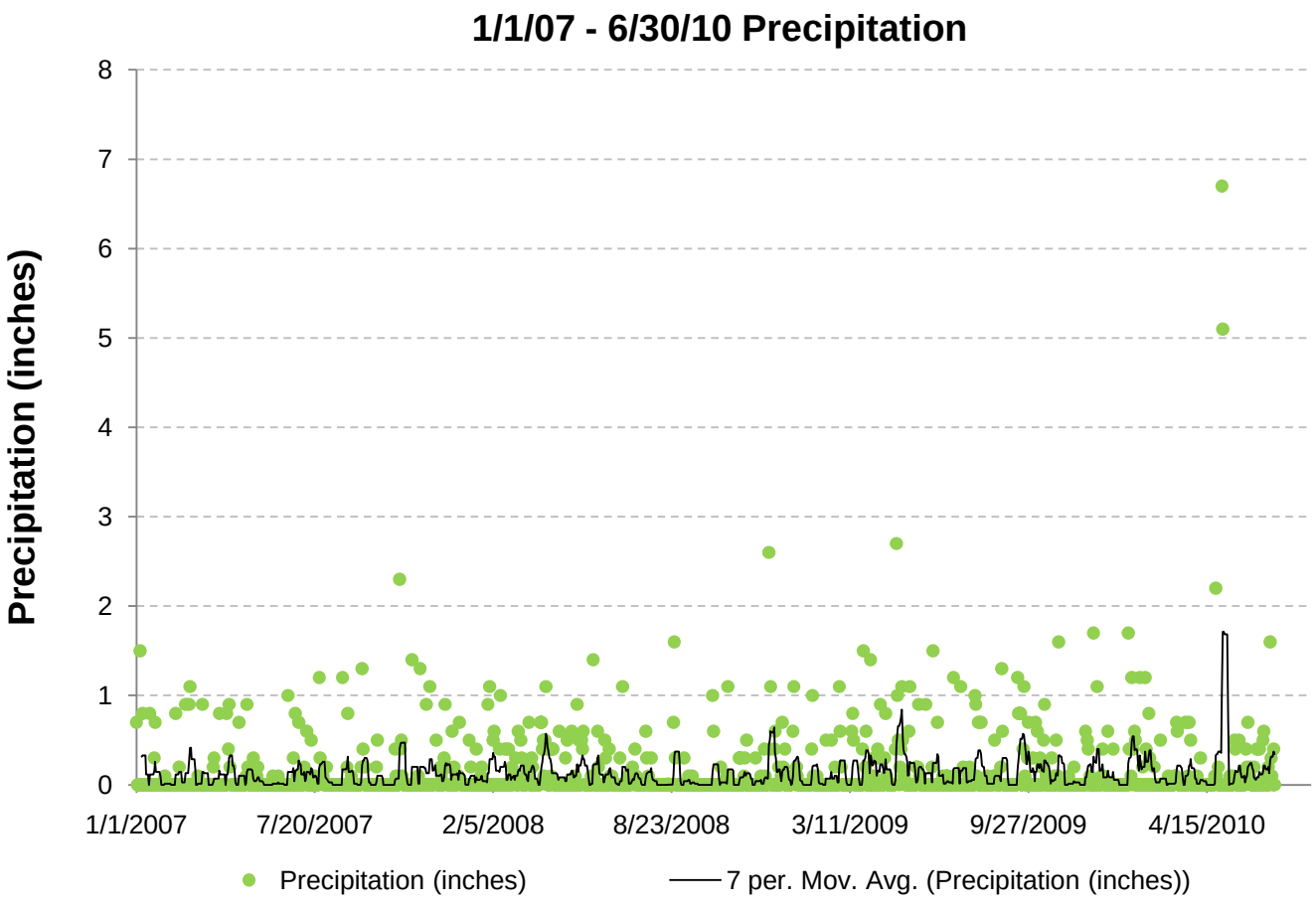
1/1/07 - 6/30/10 Murfreesboro SCWWTP Effluent Phosphorus

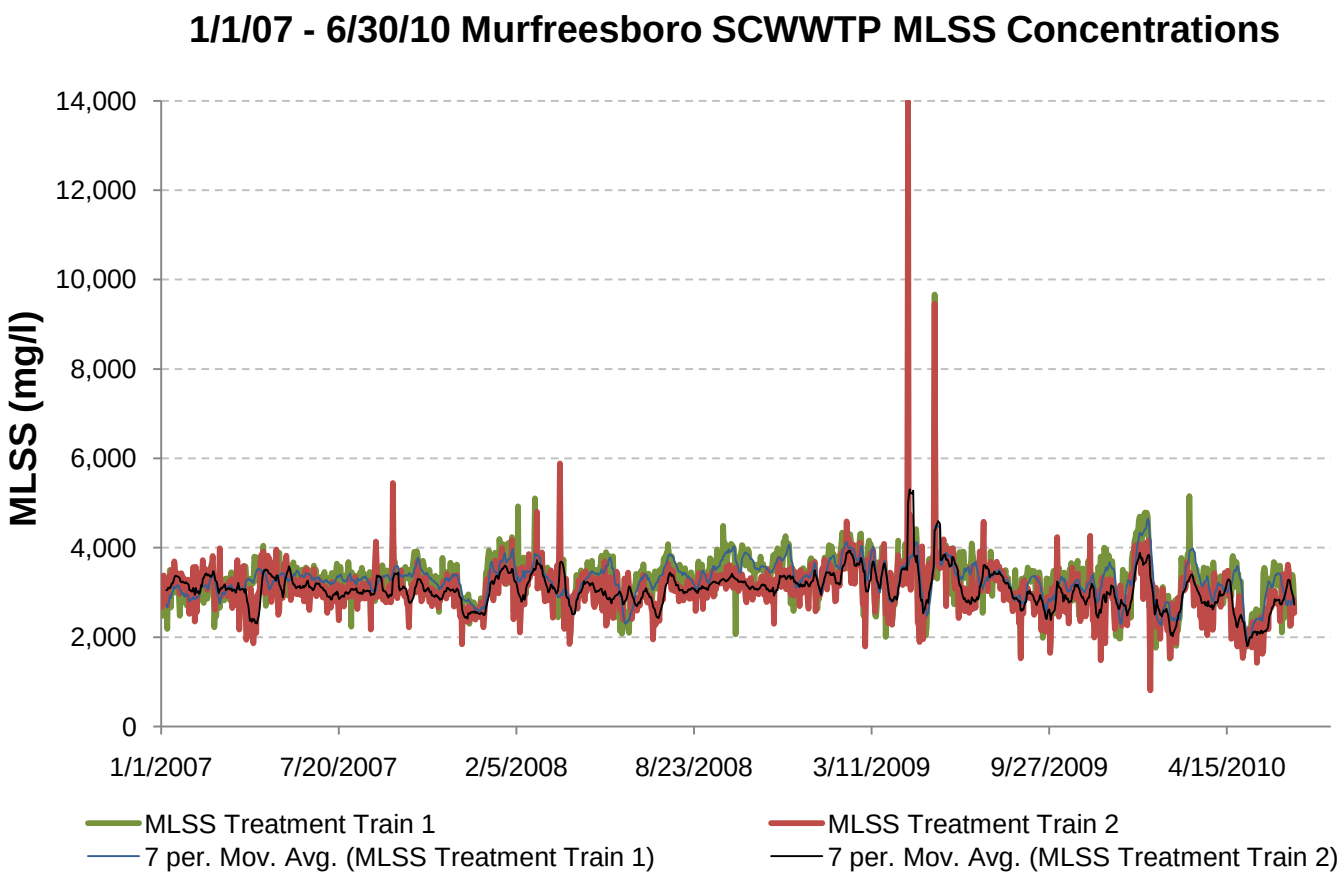


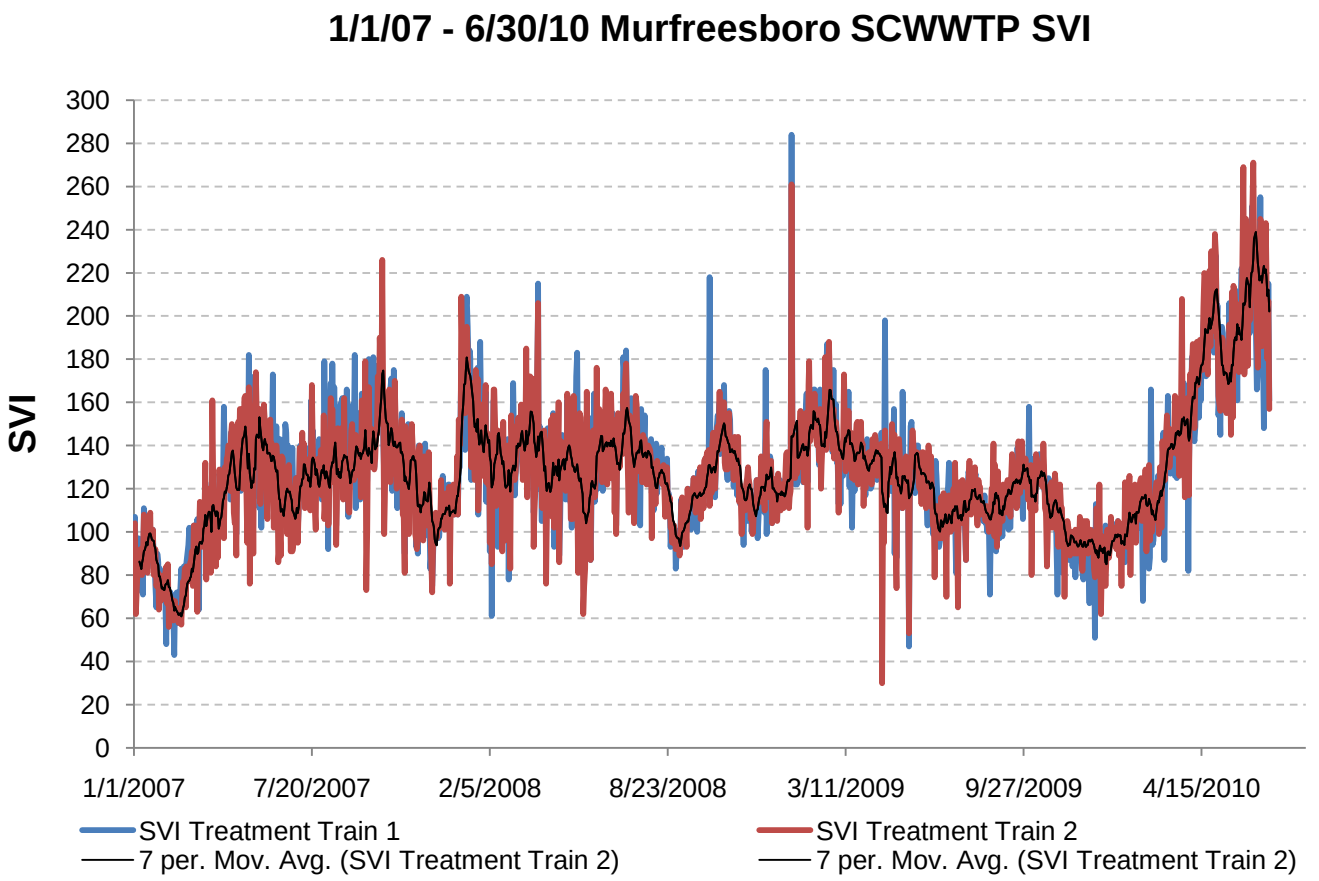
1/1/07 - 6/30/10 Murfreesboro SCWWTP Final Effluent E. Coli

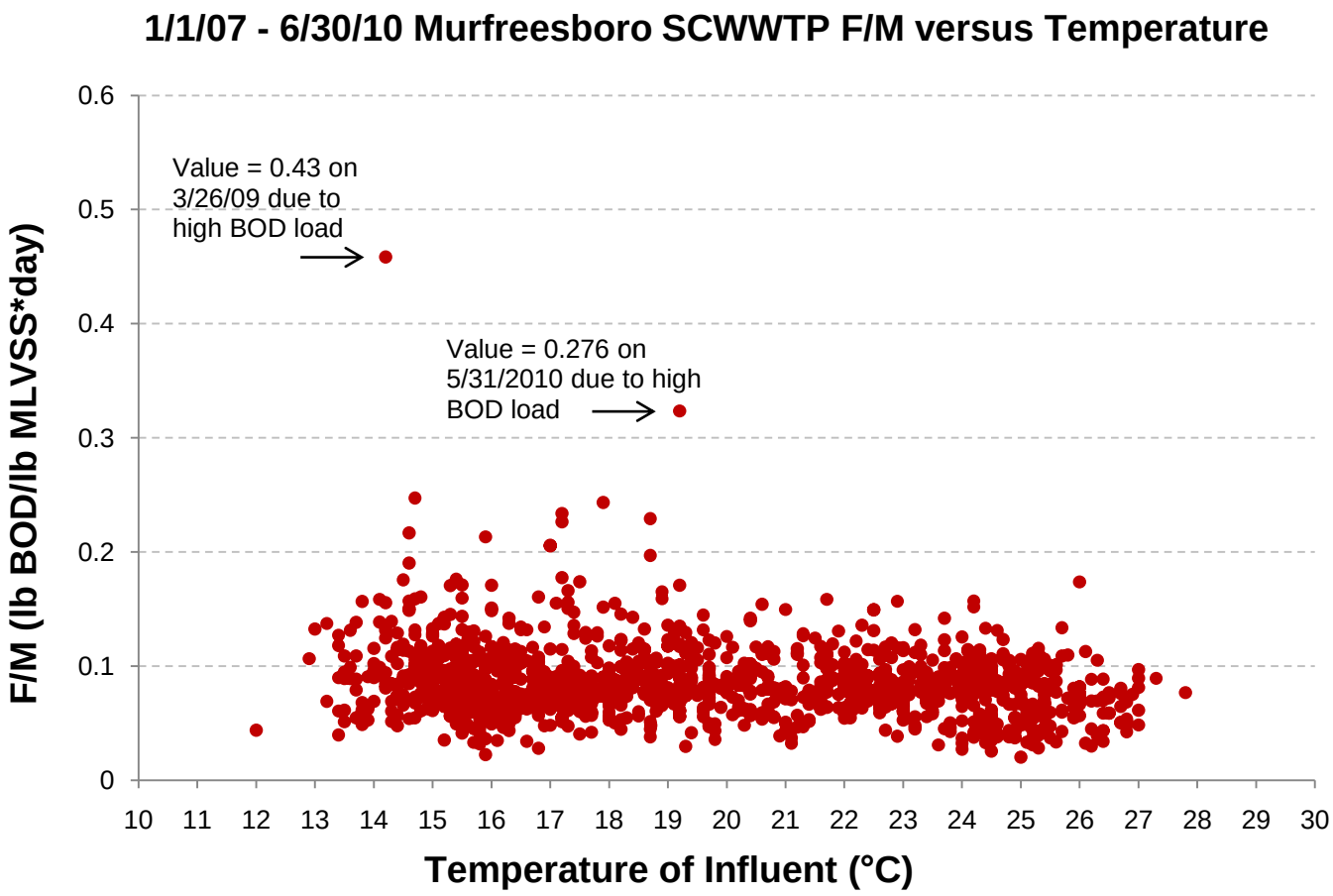



1/1/07 - 6/30/10 Murfreesboro SCWWTP Effluent Dissolved Oxygen
Effluent Dissolved Oxygen (mg/l)
16
14
12
10
8
6
4
2
0
1/1/2007
7/20/2007
2/5/2008
8/23/2008
3/11/2009
9/27/2009
4/15/2010
Daily Instantaneous Minimum Permit Limit= 6 mg/l
Effluent Dissolved Oxygen (mg/l)


1/1/07 - 6/30/10 Precipitation
Precipitation (inches)
8
7
6
5
4
3
2
1
0
1/1/2007
7/20/2007
2/5/2008
8/23/2008
3/11/2009
9/27/2009
4/15/2010
Precipitation (inches)
7 per. Mov. Avg. (Precipitation (inches))

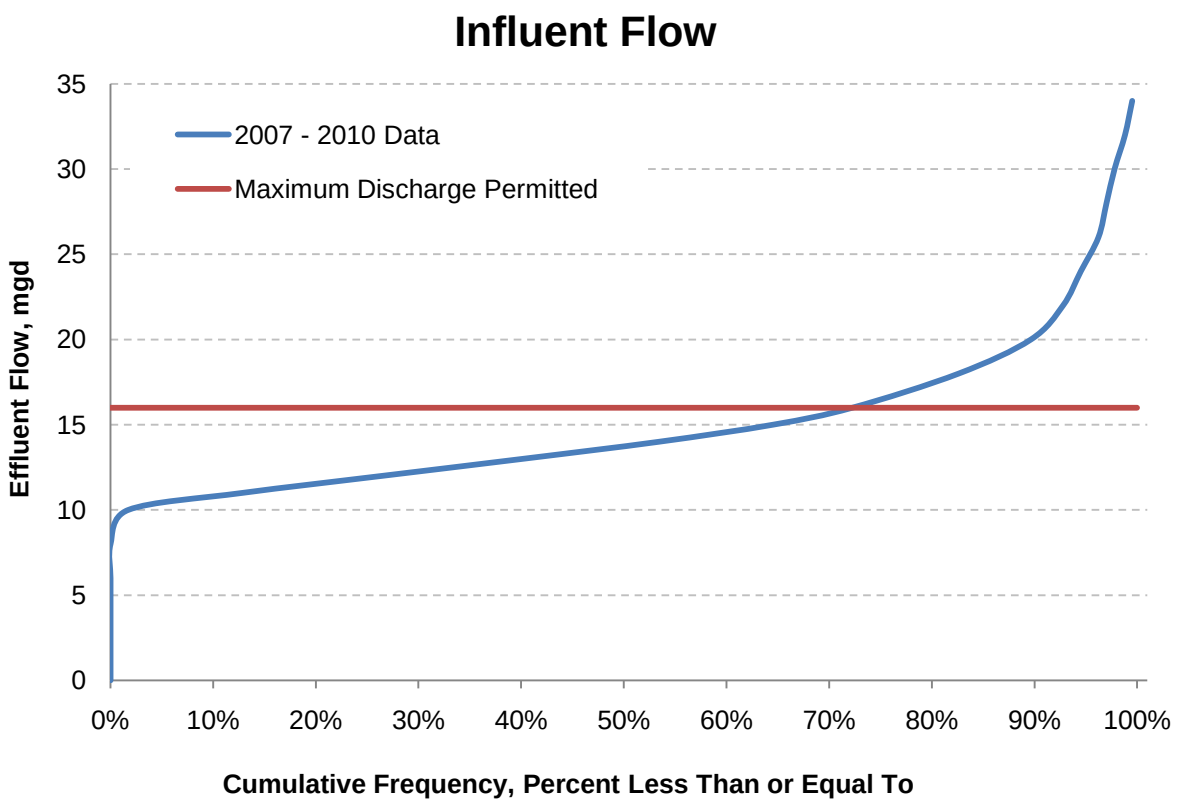

1/1/07 - 6/30/10 Murfreesboro SCWWTP MLSS Concentrations
MLSS (mg/l)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1/1/2007
7/20/2007
2/5/2008
8/23/2008
3/11/2009
9/27/2009
4/15/2010
MLSS Treatment Train 1
MLSS Treatment Train 2
7 per. Mov. Avg. (MLSS Treatment Train 1)
7 per. Mov. Avg. (MLSS Treatment Train 2)

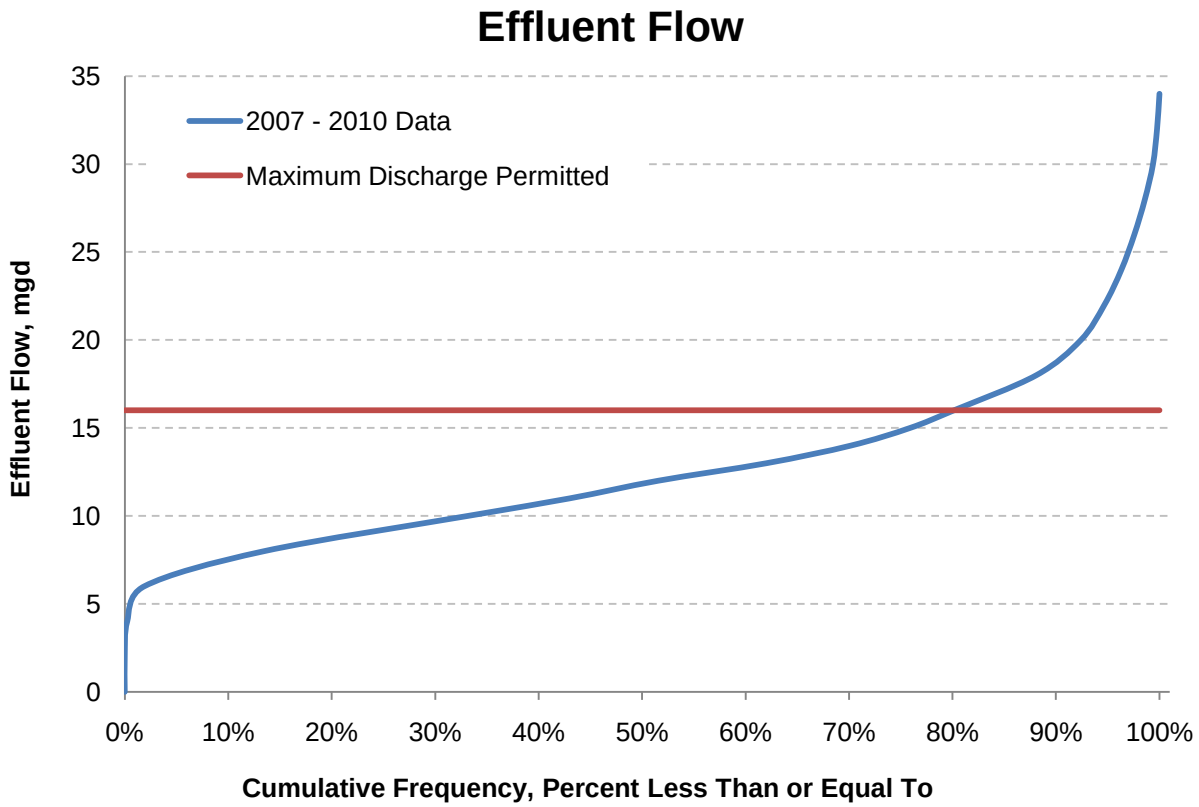

1/1/07 - 6/30/10 Murfreesboro SCWWTP SVI
SVI
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
1/1/2007
7/20/2007
2/5/2008
8/23/2008
3/11/2009
9/27/2009
4/15/2010
SVI Treatment Train 1
SVI Treatment Train 2
7 per. Mov. Avg. (SVI Treatment Train 2)
7 per. Mov. Avg. (SVI Treatment Train 2)


1/1/07 - 6/30/10 Murfreesboro SCWWTP F/M versus Temperature
F/M (lb BOD/lb MLVSS*day)
0.6
0.5
0.4
0.3
0.2
0.1
0
Value = 0.43 on 3/26/09 due to high BOD load
Value = 0.276 on 5/31/2010 due to high BOD load
10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Temperature of Influent (°C)

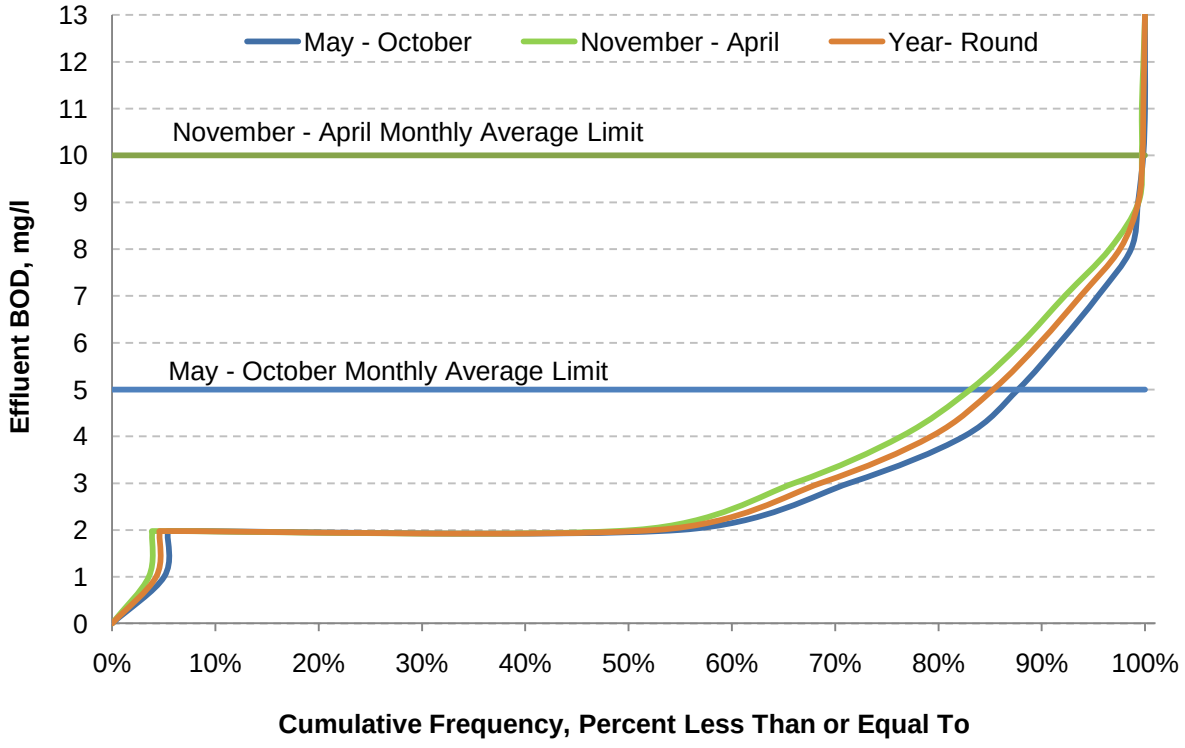
ATTACHMENT C

Graphical Illustration of Effluent Parameter Cumulative Frequency

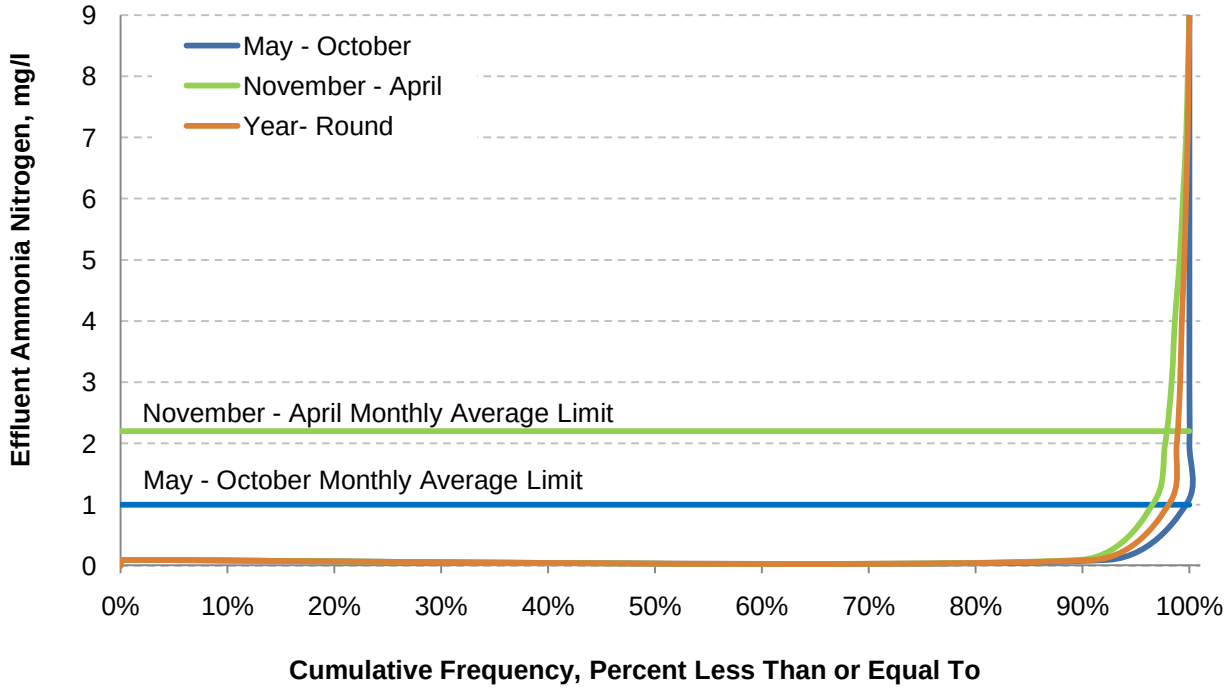

Influent Flow
2007 - 2010 Data
Maximum Discharge Permitted
Effluent Flow, mgd
35
30
25
20
15
10
5
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Cumulative Frequency, Percent Less Than or Equal To


Effluent Flow
2007 - 2010 Data
Maximum Discharge Permitted
Effluent Flow, mgd
35
30
25
20
15
10
5
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Cumulative Frequency, Percent Less Than or Equal To

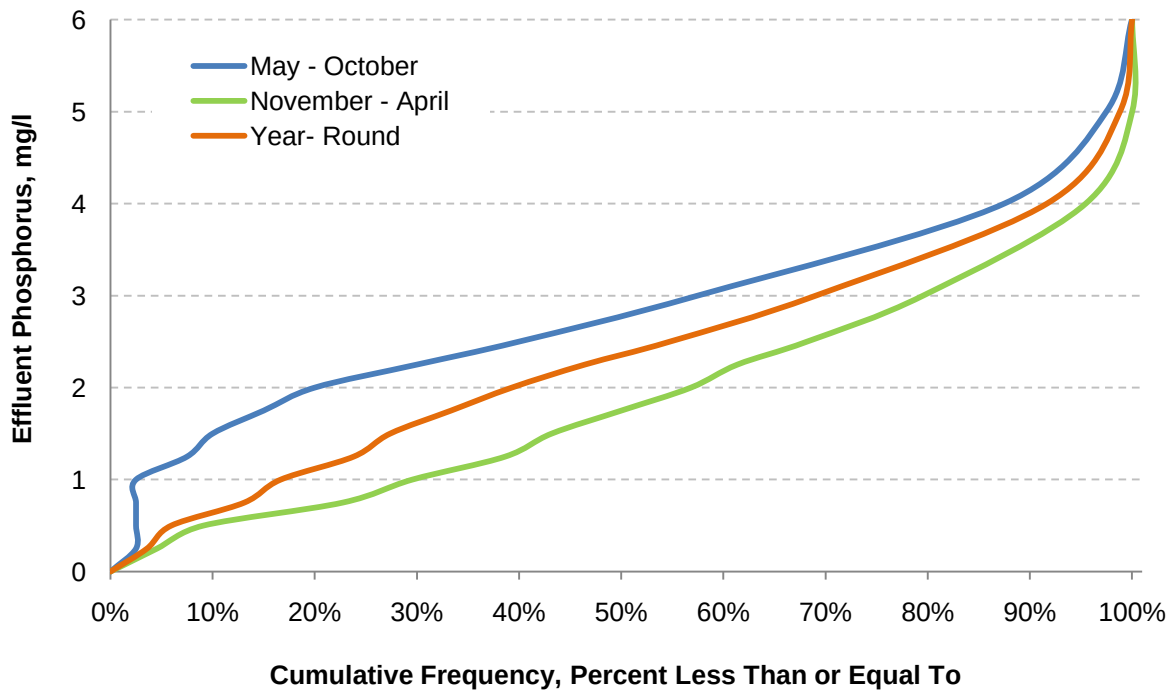
Seasonal Effluent 5-Day CBOD, 2007 - 2010



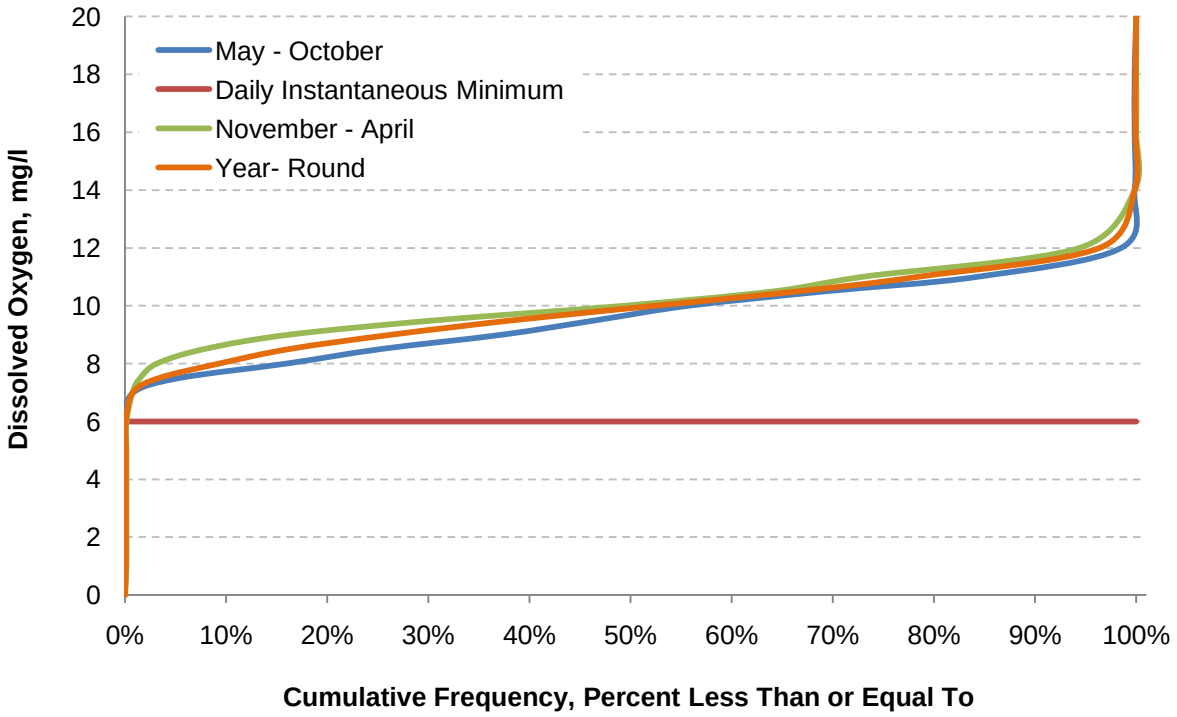
Seasonal Effluent Ammonia Nitrogen, 2007 - 2010



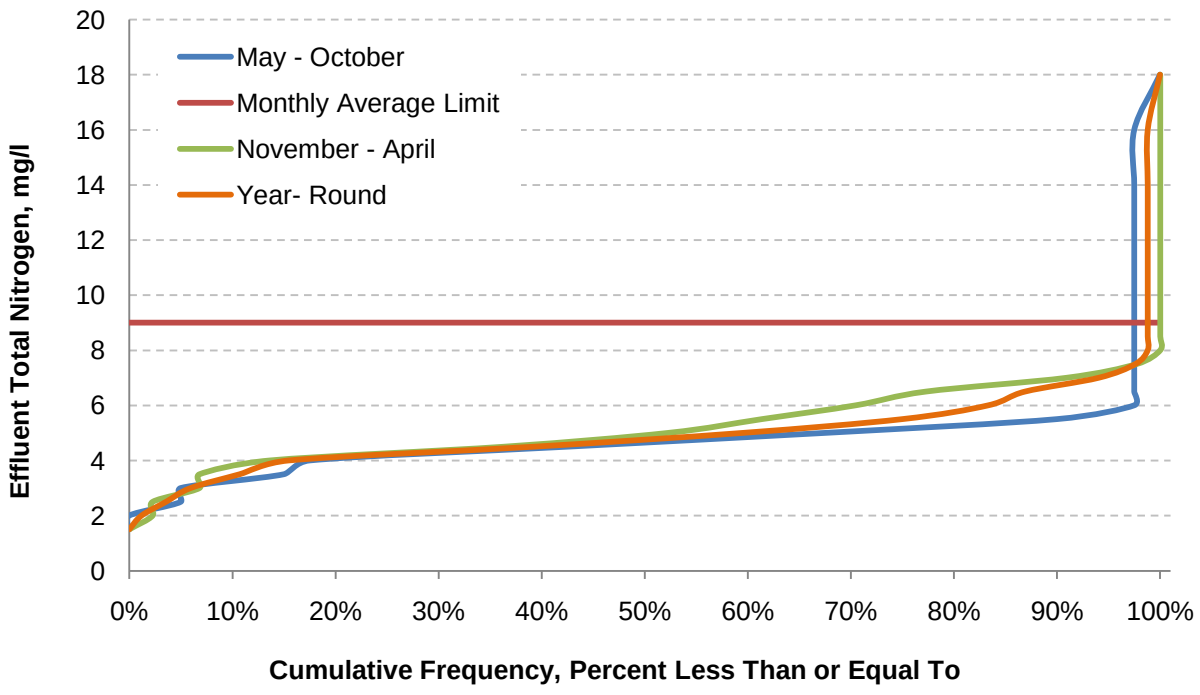
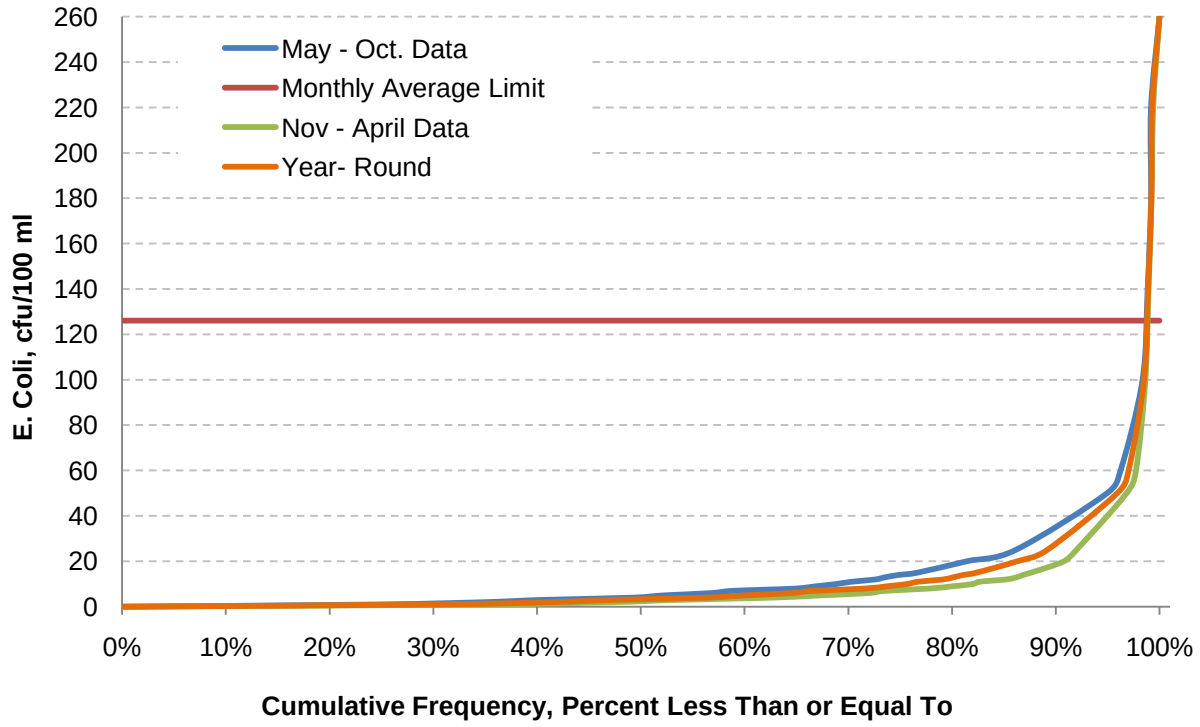
Seasonal Effluent Phosphorus



Seasonal Effluent Dissolved Oxygen



Seasonal Final Effluent Total Nitrogen



Seasonal Final Effluent E. Coli