SWMP Document No.:	20.120-126, 40.140-143
Subject line:	Stream Monitoring
Description:	Stream monitoring – all sampling and monitoring specified in permit
Permit Ref.:	3.1, 5.1, 5.2
Lead Dept.:	Murfreesboro Water Resources
Owner:	Josh Upham

1. The city of Murfreesboro has a monitoring program that consists of NPDES permit and TMDL requirements, with additional activities designed to identify sources of pollution, to gage effectiveness of the stormwater program, and to develop corrective action plans.

    a. All monitoring records will include:

        i. Date, latitude and longitude, time
        ii. Names of staff involved
        iii. Analytical techniques
        iv. Results

    b. Monitoring activities will be recorded and updated in the following locations and documents:

        i. In SWMPP
        ii. In house file system (on-file in report form, spread sheet)
        iii. In stormwater database in GIS (see GIS mapping procedure)
        iv. In watershed management plans
        v. In corrective action plans
        vi. In pollutant reduction dashboards

    c. Staff will follow safety procedures while monitoring and sampling.

2. Analytical monitoring (*5.1*)

    a. Biological monitoring

        i. Professional biological and habitat assessments must be performed on stream segments identified as having unavailable parameters (impairment) for siltation, habitat alteration and/ or nutrients using Semi-Quantitative Single Habitat (SQSH) methods as outlined in the most recent version of the Tennessee Division of Water Resources Quality System Standard Operating Procedure for Macroinvertebrate Stream Survey (QSOPMSS).

1. For compliance of this permit requirement the city will hire professional biologists as described in the QSOPMSS. Biologist credentials and lab descriptions will be provided in response to request for quotes.
2. It must be written in the request for quotes that professional biologists perform and analyze samples using procedures described in the QSOPMSS.
3. Appropriate sampling sites will be located by city staff to represent stream segments with adequate flow.
4. Samples should not be collected in losing stream segments.
5. Professional biologist selected must provide adequate reports with results and accepted metrics including EPT and TMI.
6. All stream segments with unavailable parameters or impairments must be sampled in a five-year period.

ii. Baseline macroinvertebrate sampling. In addition to sampling required by permit, biological samples will be collected bi annually for all TDEC designated stream segments in the city. This sampling is to gage the effectiveness of the stormwater program and to track health of local streams.

1. Samples should be collected using SQSH methods described in the QSOPMSS.
2. Samples must be analyzed by a lab using methods described in QSOPMSS.
3. The lab must meet qualifications specified in QSOPMSS.
4. Lab report should note appropriate metrics such as TMI, EPT.
5. Lab findings, especially TMI, will be recorded in watershed management plans, pollutant reduction dashboards, and plotted in water quality baseline to be available for viewing.
6. Baseline macroinvertebrate sampling should not be used to satisfy permit require 5.1.
7. Baseline macroinvertebrate sampling will be used in gaging improvement in TMDL stream segments and gaging effectiveness of stormwater program.

iii. Cursory biological sampling. This is an optional in-house biological sampling method where trained staff identify the abundance of macroinvertebrate species using known keys such as from the Isaac Walton League. Cursory sampling allows staff to get a snapshot of a sample site by calculating a score using the Murfreesboro Macro Invertebrate Index (MMI, not for official use).

1. Staff will use a kick or D-shaped net to collect a macroinvertebrate sample from an appropriate sample location.
2. Using a macroinvertebrate key, staff will identify species and note abundance as described in the MMI.
3. Points are given based on species abundance and sensitivity resulting in an MMI score.
4. Findings will be recorded in watershed management plans, pollutant reduction dashboards, and on file in report form.

5. Note: MMI scores don't necessarily predict water quality but provide reference from year to year.
6. Staff should be cautious not to over excavate or excessively sample a site.
7. Staff uses cursory sampling to better track changes in restored stream segments or when there is a suspected change in water quality.

b. Bacteriological sampling

iv. City, led by MWRD Stormwater staff, will perform bacteriological sampling in stream segments with unavailable parameters (impairment) for pathogens using methods described in the most current version of the Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water (QSSOPCBSW).

1. Staff must collect five samples within a thirty-day period to establish a geometric mean.
2. Samples must be collected in summer months (March though November) to distinguish between baseflow loading and stormwater runoff.
3. Flow measurements will be obtained with each sample.
4. Findings will be recorded in a report stored digitally and on file and in SWMP.
5. Findings will be updated in watershed management plans and pollutant reduction dashboards.
6. Collection and lab analysis procedures will be consulted in the latest version of QSSOPCBSW.

v. City uses bacteriological sampling also for IDDE investigations, TMDL source tracking, and to gage effectiveness of BMP's. See TMDL monitoring for further detail.

vi. Spring sampling. Many of Murfreesboro's stream segments are fed by shallow karst systems which mix with surface water. Major springs should be sampled every one or two years for source tacking purposes.

3. Non-analytical monitoring (*5.2)*

a. Visual Stream Assessment (VSA's) and watershed characterizations

i. City staff must perform VSA's on each stream segment within MS4 jurisdiction with unavailable parameters for siltation, habitat alteration, pathogens and nutrients to identify and prioritize pollutants of concern.

ii. VSA's will be performed throughout HUC-12 sub watersheds.

iii. To best understand the condition of local streams all stream segments within the city will be assessed cyclically based on the watershed cycle outlined below.

iv. Stream segments with unavailable parameters will be assessed within a five-year period.

v. Observations made during VSA's will be ranked based severity, ability to correct, and accessibility. These findings will be noted in corrective action and watershed plans.

vi. A device will be used that supports mobile GIS mapping applications so that observations can be updated in existing VSA features. Images and attribute information should be collected for each observation point taken.
vii. A variety of existing stream assessment protocols will be consulted regularly.
viii. Changes in stream conditions will be noted such as increasing bank erosion in VSA reports.
ix. VSA reports will be either in long format or in the form of graphical maps.

4. TMDL monitoring (*3.1*)

a. Source tracking

i. Spring sampling for bacteria.

1. Major springs will be sampled during both high flow and baseflow conditions for bacteria.
2. Precipitation before sample should be noted.
3. If possible, flow should be collected for CFS.
4. Results will be recorded in report form on file and in watershed management plans.
5. Major springs: Murfree, Black Fox, Maney, Vanderford/Wallace, Alexander, York, Riverrock, Three Rivers, Military, Barfield.

ii. Urban storm basin outfall sampling for bacteria in first flush.

1. Highly impervious sub basins will be located within watersheds of TMDL listed streams preferably with single discharge points.
2. Bacteria samples will be collected at the onset flow from outfall pipe and thereafter every 15 minutes for a total of an hour if flow hasn't ceased.
3. Sampling after extended dry periods should be a priority to gage bacteria buildup in drainage system.
4. Results will be recorded in sampling GIS database, in report form on file, in pollutions reductions dashboards, and in watershed management plans.

b. Gaging effectiveness of SCMs

i. Outfalls will be sampled for bacteria where SCM's or retrofits have been installed in the associated basin.
ii. Baseline macroinvertebrate sampling (described above) will be used to gage improvement in TMDL stream segments where SCM's or retrofits have been installed in riparian buffers and added tree canopy in the watershed.
iii. When needed, sampling will be performed to calibrate models used to gage the effectiveness of BMP's.
iv. Outfalls will be screened for TSS in segments where SCM's have been installed to gage effectiveness.
v. Outfall screening can be combined with the IDDE program outlined in the IDDE procedure.

vi. Outcomes will be recorded in watershed management plans and pollutant reduction dashboards.

5. Ambient monitoring

Staff will collect a variety of parameters not described in NPDES permit requirements in order better understand water quality and hydrology of all streams as the opportunity presents itself.

a. Ph, temperature, flow, conductivity, nitrate, phosphorous, ammonia,etc….
b. Staff should encourage sampling and monitoring cooperatives with able city departments such as Parks and Recreation.
c. Staff should support citizen sampling programs including with schools with access to sampling locations.

6. Watershed Cycle

All streams of a sub watershed will be the focus of assessments and increased monitoring in a scheduled year as specified in the watershed cycle. The watershed cycle allows for the health of stream to be observed over time.

a. Sub watersheds in watershed cycle

Sinking Creek Watershed - Overall Creek Watershed (Puckett Creek, Armstrong Branch) - East Fork Stones River/ Bear Branch Watershed (Bushman Creek, Garrison Creek, Dry Branch) - Upper West Fork Stones River Watershed (Spence Creek) - Middle Fork Stones River Watershed - Lytle Creek Watershed (Town Creek - Black Fox Spring, Lee Springs Branch, Todd Lake)

b. Activities within annual cycle

i. Spring

1. Sub watershed-based education and outreach
2. Macroinvertebrate sampling (baseline, cursory, professional)

ii. Summer

1. Baseflow stream and spring bacteriological sampling
2. Dry weather outfall bacteriological sampling
3. Public meetings and public insight
4. Baseflow flow measurements

iii. Fall

1. IDDE dry weather screening (outfalls, hot spot/ significant contributors)
2. Visual Stream Assessments (VSA) and ambient monitoring
3. Pollutant reduction dashboard to be attached to annual report

iv. Winter

1. Report compilation
2. Planning

c. Schedule

2018-2019 (Lytle Creek), 2019-2020 (Upper West Fork Stones River), 2020-2021 (Sinking Creek), 2021-2022 (Lower West Fork Stones River), 2022-2023 (Overall Creek)

7. Stream restoration monitoring

a. Where stream or habitat restoration projects occur staff will assess progress.

i. Apply existing macroinvertebrate sampling as results relate to eco reference streams
ii. Note in-stream habitat improvements
iii. Note buffer condition and growth
iv. Note stability of banks

8. Pollutant reduction dashboards

a. Pollutant reduction dashboards provide quick information about pollutant reduction in a watershed.

i. Dashboard will be limited to a single page
ii. biological sampling
iii. bacteriological sampling
iv. acres treated with SCM's
v. acres treated with WQPA or vegetated buffers
vi. outreach and education numbers
vii. clean up numbers (pounds/ tons)
viii. landuse percentages relative to previous year (imperviousness, canopy)
ix. linear feet of stream improvement

9. Roles and staff needs

a. Sampling teams will consist of two people when possible.

b. NPDES and TMDL monitoring and sampling will be conducted by Murfreesboro Water Resources staff and approved by NPDES Program Coordinator.

i. Water Quality Specialist – planning and scheduling, watershed management plans, pollutant dashboards, reports, data collection.
ii. Water Quality Technician – assistance, photography, data collection

c. Parks and Recreation staff may conduct sampling and monitoring in streams traveling in and along park and greenway property.

   i. Data points will be added to shared databases.

10. Murfreesboro Macroinvertebrate Index:

    Score is achieved by locating species tolerance and abundance in below table where a score greater than 12 may indicate good water quality and score lower than 8 may indicate poor water quality.

Very Sensitive/ EPT	Sensitive	Moderate	Tolerant
water penny	riffle beetle	odanata	hirudinea
may fly	gastropoda	amphipoda	oligochaeta
stone fly	Isopoda	cray fish	diptera
caddis fly		megolptera	
		bivalves	

Table 1: species tolerance list

Very Sensitive/EPT	Quantity Code	Score
	dominant/abundant	2.5
	common	2
	rare	1.5
Sensitive	dominant/ rare	2
	common	1.5
	rare	1
Moderate	dominant/ rare	1.5
	common	1
	rare	.5
Tolerant	dominant/ rare	1
	common	.5

Table 2: MMI scoring chart

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