# Quality Assurance Project Plan

## City of Columbia Water Quality Monitoring as Required for Supplemental Environmental Projects (SEP)

Prepared by City of Columbia Department of Utilities & Engineering

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Project Location: Station 1 – C-001 – Gills creek @ Garners Ferry Road

Station 2 – B-280 – Smith Branch @ North Main Street

Station 3 – C-017 – Gills Creek @ Bluff Road

## SIGNATORY PAGE:

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# 1. Project Management

## 1.1. Distribution List

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| Ashley Amick | Access Analytical, Inc. | aamick@axs-inc.com |

## 1.2 Project/Task Organization

The tasks of the City of Columbia's QAPP will be to monitoring 4 parameters at 3 different S.C. DHEC established water quality monitoring stations for a period of 6 years. Concurrently, there will be Supplemental Environmental Projects occurring at various stages of completion and activity. The goal is to compare the water quality monitoring data collected during these improvement projects to the historical DHEC data at these stations. This will help determine the overall success of the projects efforts as well as indicate the current level of water quality in these areas. The following is a breakdown in general responsibility:

Project Manager / City of Columbia Staff (City of Columbia) - Will manage the project including developing and maintaining the QAPP and submitting reports to hand off to CDM Smith and EPA, per the Consent Decree Schedule.

Access Analytical – Will perform field analysis / sampling and confirm / compile data for City reports.

Nydia Burdick (SCDHEC QA/QC) – Will review and approve the QAPP.

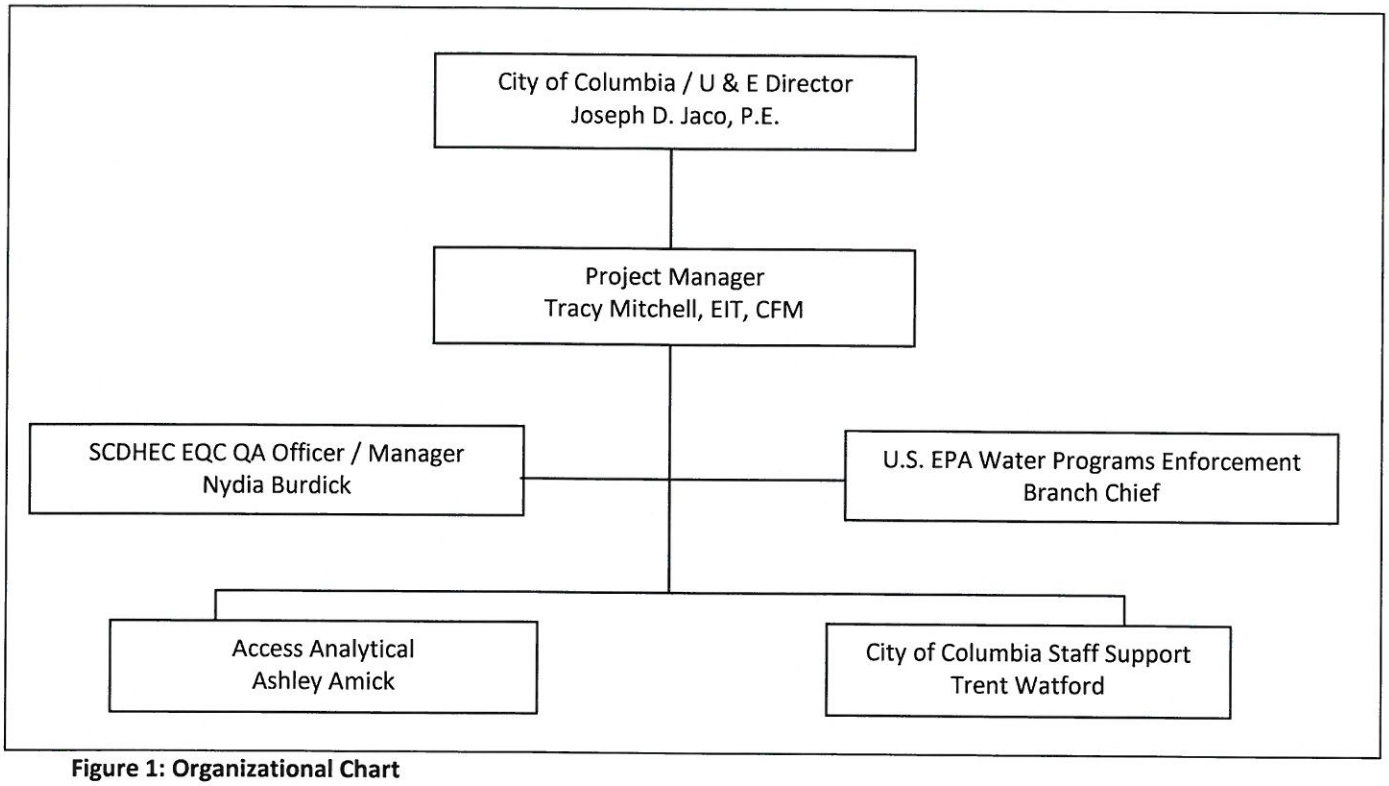


**Figure 1: Organizational Chart**

## 1.3 Problem Definition / Background

Effective May 21, 2014, the City of Columbia (Columbia) entered into a Consent Decree (CD) as a result of violations of the Clean Water Act through the City's Wastewater Program. Among the objectives of this CD, the City agreed to implement a program for ambient monitoring of four different parameters at the three existing monitoring stations, as requested by DHEC and EPA that correspond to Supplemental Environmental Projects (SEP). This information is being collected to comply with the Water Quality Monitoring Component of Revised Appendix I of the CD.

## 1.4. Project / Task Description / Schedule

I. Monitoring

The City of Columbia will implement a program for ambient monitoring of dissolved oxygen (DO), total suspended solids (TSS), temperature (temp) and *E. coli*[1] at the monitoring sites listed below. Columbia will conduct the monitoring in accordance with an approved South Carolina Department of Health and Environmental Control (DHEC) quality assurance project plan (QAPP). Columbia will have the TSS and *E. coli* data analyzed at a DHEC certified lab.[2] By using established monitoring sites, water quality data collected by Columbia will be available for comparison to historic water quality data taken by DHEC for assessment purposes.

Within sixty (60) days of entry of the Consent Decree (May 21, 2014), Columbia is required to submit this QAPP to DHEC for review and approval. Columbia will begin monitoring within thirty (30) days of DHEC's approval of the QAPP. As indicated below, Columbia will monitor quarterly for the first 3 years under the Consent Decree and monthly (or every other month at Site C-17) from years 4 through 6 under the Consent Decree.

**II.** Water Quality Stations (see attached map):

| Site | Description | Impairment | TMDL | Monitoring Parameters | Frequency |
|---|---|---|---|---|---|
| C-001 | Gills Creek @ Garners Ferry Road | Fecal Coliform | Yes | DO<br>*E. Coli*<br>Temp<br>TSS | Quarterly during years 1-3; Monthly during years 4-6 |
| B-280 | Smith Branch @ North Main Street | Fecal Coliform | Yes | DO<br>*E. Coli*<br>Temp<br>TSS | Quarterly during years 1-3; Monthly during years 4-6 |
| C-017 | Gills Creek @ Bluff Road | Fecal Coliform; Dissolved Oxygen | Yes | DO<br>*E. Coli*<br>Temp<br>TSS | Quarterly during years 1-3; Monthly during years 4-6 |

1 *E. coli* standard replaces the existing fecal coliform standard.
2 The temp and DO parameters measured in the field with a probe are not subject to the certified laboratory requirement

**Table 1: Water Quality Monitoring Stations/Sites**

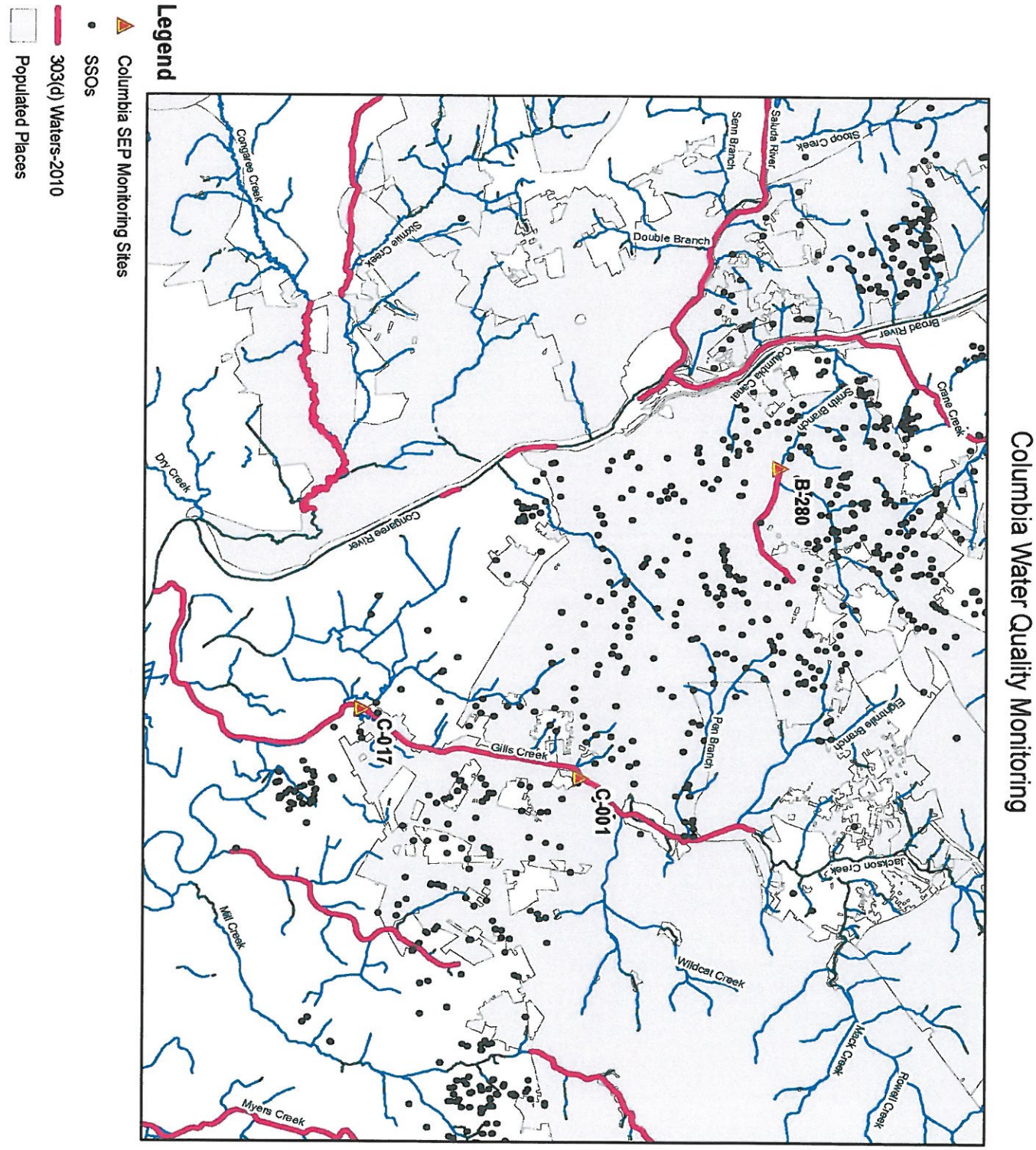


**Figure 2: Map of DHEC Monitoring Stations / Sampling Sites**

## 1.5. Data Quality Objective (DQOs) and Data Quality Indicators (DQIs)

### 1.5.1 The DQO Process

a. **State the Problem:** The goal of this project is to monitor four specific parameters at three established DHEC water quality monitoring stations within the Gills Creek (Gills Creek) and Broad River Watersheds (Smith Branch) for 6 years. This monitoring will be performed quarterly during years 1-3 and monthly from years 4-6.

b. **Identify the Decision-** All data collected under this plan is collected to ensure environmental compliance. By using established monitoring sites, water quality data collected by Columbia will be available to DHEC for comparison to historic water quality data taken by DHEC for assessment purposes.

c. **Inputs to the Decision-** Lab and field data, in addition to historical data from DHEC monitoring

d. **Define the Study Boundaries-** The study boundaries are noted and discussed in Section 1.4 and Figure 2. At each sampling site within the study boundaries, water samples will be collected at a depth of 6-12 inches.

e. **Develop an analytical approach and a decision rule-** All data collected under this plan is collected to ensure environmental compliance with the SEP. No future efforts are planned based on the outline of this plan.

f. **Specify Limits on Decision Error**- See Section 2.5 for information on error-minimization strategies used in this study.

g. **Optimize the design for obtaining the data**- The quality of measurements made for the plan by the laboratory is determined by the following data quality indicators

(DQIs), or characteristics: representativeness, accuracy, precision, detectability, completeness, and comparability. Specific criteria for each characteristic were established to assist in the selection of appropriate sampling and analytical protocols and to identify applicable documentation, sample handling procedures, and measurement system procedures. These DQI criteria were established based on site conditions, requirements of the project, and knowledge of available measurement systems, and were addressed whenever appropriate for the data generated.

### 1.5.2 Representativeness

Representativeness is a qualitative measure of the extent to which a sample acquired from a matrix describes the chemical or physical characteristics of that matrix. Sample collection, handling (e.g., splitting, preservation, storage), and measurements are all conducted according to protocols allowing for the highest degree of representativeness possible for the sample media (air, soil, water, etc.). Recording procedures are utilized which document adherence to proper protocols and maintain sample identification and integrity.

### 1.5.3 Accuracy

Accuracy describes the degree of agreement between an observed value and an accepted reference (true) value. It includes a combination of random error (precision) and systematic error (bias) components which are introduced in sampling and analytical operations. DQI criteria for accuracy are established through quality control limits for each parameter measured and for each analytical technique, per matrix where applicable. These objectives are assessed through the analysis of sterility checks, positive and negative culture checks, blanks, matrix spike (MS)/matrix spike duplicates (MSDs), and laboratory control samples (LCSs), as specified by the analytical method, required by the project, or generated and updated from data acquired through required quality control measurements. Nominal quality control limits for each parameter and analytical technique are specified in the analytical methods.

### 1.5.4 Precision

Precision is a measure of the reproducibility of an analysis under a given set of conditions, regardless of the true value of the target analyte in a sample. The overall precision of a sampling event has both a sampling and an analytical component. DQI criteria for precision are established through quality control limits for each parameter measured and for each analytical technique, per matrix where applicable. These objectives are assessed through the analysis of MSDs (if practical), LCS duplicates (if available), field duplicates, laboratory replicates, and split laboratory samples, as specified by the analytical method,

required by the project, or generated and updated from data acquired through required quality control measurements. Nominal quality control limits are specified for each parameter and analytical technique in the analytical methods.

### 1.5.5 Detectability

Method detectability objectives define the lowest concentration or quantities required of the measurement system for each analyte or parameter. The laboratory has established reporting limits (RLs) which are the minimum concentrations to be reported without qualification for routine laboratory conditions. Data quality indicator criteria for detectability (i.e., RLs) are established for each parameter measured and for each analytical technique. These criteria are specified by the analytical method, required by the project, or determined and updated from data acquired through required quality control measurements (e.g., the replicate analyses of samples or standards containing low concentrations of the analyte of concern).

The RL for an analyte is a function of the specific analytical procedures and can vary substantially as a result of dilutions and similar procedure modifications. In all cases, the RL necessary to fulfill data quality objectives is confirmed by laboratory measurements. Nominal RLs for each parameter and analytical technique are listed in the analytical methods and on the report of analysis.

### 1.5.6 Completeness

The characteristic of completeness is a measure of the amount of valid data obtained compared to the amount that was expected to be obtained under normal conditions. The amount of valid data expected is based on the measurements required to accomplish project objectives.

### 1.5.7 Comparability

The characteristic of comparability reflects both internal consistency of measurements and expression of results in units consistent with other organizations reporting similar data. The generation of comparable data requires operating within the calibrated range of an instrument and utilizing analytical methodologies which produce comparable results. Appropriate standard units for measurement values are utilized for each measurement system, which yields internally and externally comparable results assuming other comparability criteria are met.

### 1.5.8 Project DQIs

Because of the intended data uses, the general philosophy for determining the project's DQI criteria was that data quality should meet current industry standards for such measurement data. In general, measurement DQI criteria are based on the published

analytical method for each parameter. Specific criteria for measurement DQIs for the analyses to be performed are summarized below.

| Parameter | Units | Accuracy[a] (LCS) | Accuracy[a] (Matrix Spike) | Precision[a] (RSD or RPD) | MDL[b] | RL[c] | Complete-ness (%) |
|---|---|---|---|---|---|---|---|
| E. coli | CFU/100ml | NA | NA | RPD≤ 200% for <150 CFU/100 ml RPD≤ 100% for ≥ 150 CFU/100 ml | 1 C1 CFU/100 mL FU | *1 CFU/100 mL if sample is not diluted* | |
| Total Suspended Solids (TSS) | mg/L | 90-110% | NA | ≤5% | ≥2.5 mg to ≤200 mg | *≥2.5 mg to ≤200 mg* | |
| Dissolved Oxygen | mg/L | 90-110% | NA | ≤25% | <0.3 | *<0.3* | 95 |
| Water Temperature | °C | ± 0.5°C | NA | ± 0.5°C | NA | *NA* | 95 |

LCS = laboratory control sample
MDL = method detection limit
MS = matrix spike
NA = not applicable
% R = percent recovery
RL = reporting limit
RPD = relative percent difference
% RSD = percent relative standard deviation

[a] Criteria apply to concentrations ≥ RL.
[b] For undiluted samples.
[c] For undiluted samples. If sample is diluted, RL is proportionally higher.

**Table 2: Criteria for Measurement DQIs**

## 1.6 Special Training Requirements and Certifications

The Certificate issued by the SC DHEC Office of Environmental Laboratory Certification for Access Analytical, Inc. is 32575001.

The generation of reliable data by a laboratory requires that all operations are conducted by knowledgeable and trained personnel. The laboratory requires the accomplishment of a prescribed sequence of training objectives by a staff member before that individual is designated as qualified and permitted to independently conduct any assignment or analyses. The indoctrination and qualification process includes as a minimum:

- Reading and understanding applicable laboratory SOP,

- Reading and understanding applicable reference documents,
- Hands-on training under the supervision of an experienced and qualified individual, and
- For analytical methods used for measurements, a successful initial demonstration of analytical capability (i.e., IDC) by performing four replicate measurements which satisfy precision and accuracy criteria for the method as well as an MDL study.

Training records for staff are maintained by the Laboratory Director or Supervisor of the lab contracted to perform the work, and training files are kept for each staff member in the training and qualification files. Lab analysts shall also collect samples and perform field measurements. A summary of training accomplishments is recorded on file on the contracted lab's premises. Otherwise, no additional, specialized training will be needed for this project.

## 1.7 Documentation and Records

The QAPP will be maintained, revised, managed and facilitated by City of Columbia Staff, as listed in the Organizational Chart with the Project Manager as primary lead. S.C. DHEC's Quality Assurance Manager will review modifications pertaining to the QAPP and grant approval. Updates or changes regarding the QAPP will be e-mailed to individuals on the distribution list, unless otherwise specified. Sample collection times, field observations, and etc. will be recorded within a separate logbook by laboratory staff, as appropriate. Maps, GPS coordinates, photos, and etc. may be utilized to track progress, if necessary.

Data will be provided to the Project Manager by the lab on a quarterly basis for the first 3 years and on a monthly basis for the last three years of the project's duration. Any summaries or comments associated with the data will be drafted and finalized by the Project Manager and provided to appropriate personnel as defined in the organizational chart for distribution to all those required to receive notification pursuant to the SEP. All those required to receive notice are listed in the distribution list at the front of this document.

All raw data and/or data reports received form the lab along with summaries and commentary will be backed up, when received, to a shared folder for staff and management to access, when appropriate. Annually, electronic records will be backed up onto an external hard drive and kept for a minimum of 10 years or as defined in the Consent Decree. Hardcopies will be bound and stored for a minimum of 10 years or as defined in the Consent Decree. All records are kept onsite.

### 1.7.1 Data Reporting

After completion of analyses, analysts enter results for both samples and QC measurements into the laboratory's computer-based report templates. After peer review of the data is completed and the results are acceptable, the Laboratory Director reviews the preliminary report and works with necessary laboratory personnel to make any needed corrections. A final report is then produced and submitted to the City, either electronically or by mail depending on the contract. For this project, the laboratory will forward final reports containing completed, reviewed, and approved project results to the Program Manager pursuant to the project schedule.

The copy of the data package provided to the City and all associated raw data are typically kept for a period of at least 10 years or as defined in the Consent Decree. These records are stored in the laboratory for approximately two years, and then transferred to a storage room for secure, long term storage.

For electronic data deliverables in Microsoft Excel or similar formats, files are maintained on the laboratory's desk top computers. Backup copies of the electronic files are prepared at least annually and stored in a secure area.

# 2. Measurement/Data Acquisition

## 2.1. Sampling Process Design (Experimental Design)

The DHEC water quality monitoring stations listed in the Project Schedule table will be the focus of where sampling takes place. All samples that require analysis will be taken at the outfall of the station, with the exception of those that can be taken in the field by handheld devices and are not subject to the standards of a DHEC certified lab method.

## 2.2. Sampling Methods

As mentioned before, four parameters will be measured on a quarterly basis for Years 1-3 and on a monthly basis for Years 4-6.

Sampling efforts will involve the collection of water samples for the following analytes: total suspended solids (TSS), *E. coli*. At the time of sample collection, in situ measurements will also be made for temperature and dissolved oxygen (DO) at each sampling location through the use of calibrated field probes (YSI).

Field measurement procedures and sample collection, handling, receiving, storage, and associated record keeping procedures are integral parts of the laboratory's QA program. The policies are designed to ensure that each measurement result and each sample are

accounted for at all times. The primary objectives of measurement and sample control procedures are as follows:

- Each field measurement is recorded and uniquely identified at the time of measurement,
- Each sample received for analysis is uniquely identified,
- The correct samples are analyzed and are traceable to the applicable data records,
- Important and necessary sample characteristics are preserved,
- Samples are protected from loss, damage, or tampering,
- Any alteration of samples during collection or transport (e.g., filtration, preservation, breakage) is documented,
- Records of field measurements and sample custody (i.e., chain of custody) and integrity are established which will satisfy legal scrutiny, and
- A record of ultimate sample disposition (i.e., disposal or release from laboratory) is established.

### 2.2.1 Sample Collection

A summary of sample collection, handling, and preservation activities is provided in **Table 3.**

| Sample Type | Parameter Measured | Sample Container | Minimum Sample Size | Preservation Method/ Storage |
|---|---|---|---|---|
| Urban stream/ditch water, collected via grab samples | E. coli | Sterile plastic with sodium thiosulfate | 100 mL | Field: store in cooler at 1-6 °C<br>Lab: store in refrigerator at 1-6 °C and start analysis within 8 hours |
| Urban stream/ditch water, collected via grab samples | Total Suspended Solids (TSS) | plastic | 500 mL | Field: store in cooler at 1-6 °C<br>Lab: store in refrigerator at 1-6 °C and start analysis within 7 days |

**Table 3: Sample Collection Criteria**

Samples collected by laboratory personnel are placed in appropriate containers, having the required preservatives or additives, and labeled with site-specific information to uniquely identify each container at the time of collection. Conditions of sampling sites, sample IDs, number of samples, dates/times of collection, equipment calibrations, etc., are recorded on site in field logbooks or on laboratory chain of custody forms as appropriate. Unless otherwise specified, samples are stored on ice in coolers at 1-6 °C until their receipt at the laboratory. Samplers may be the Laboratory Director, Laboratory Master Technician and/or Laboratory Technicians trained in sampling. In general, samples collected are grab samples (i.e., sample collected at a specific time and place) and collected manually. For bacteria analysis, samples are collected using sterile glass or sterile plastic sample bottles and collected carefully at just below the outfall/station so as to not contaminate by touching the inside of either the bottle or its lid. The bottle is filled with sample to approximately one-inch from the top, and then the lid is replaced. The bottle is then placed in a snap and seal plastic bag and a cooler with ice for storage and transport to laboratory. For analyses other than bacteria, samples are collected in plastic bottles. Bottles are rinsed with river water at the site three times, carefully filled with river, capped, and then placed in a cooler for storage and transport to the laboratory. Specific procedures for sample container preparation and sample collection are provided in laboratory SOPs.

If issues occur in the field, the sample collector will handle these and record the issue and the corrective action in field books and/or logs. If the sample collector cannot fix the situation, then the Project Manager and Laboratory Director will be contacted.

## 2.3 Sampling Handling and Custody Requirements

For laboratory samplers at the time of sampling, a chain of custody (COC) form must be filled out. The following information must be recorded by samplers:

- Date sample was collected
- Time sample was collected
- Location of sample: city, general location, and specific location.
- Example for a river sample: _____
- Name of sampler
- ID of sampling bottle is the site name and the date collected.
- Analysis (e.g., bacteria) to be conducted, which must also be written in indelible ink on the sample bottle
- Environmental conditions (e.g., waves, currents, tide, wind, sky, rain, runoff)
- Describe in comments section any problems encountered during sampling and corrective actions taken

The sample collector is considered to have custody of the sample until relinquishing the sample. This sample is properly in the custody of the sampler as long as the sample is in possession of the sampler, within sight of the sampler, or locked in a secure place. When the sampler relinquishes custody he/she should sign, date, and write the time the sample was relinquished

on the COC form. The person receiving the sample should then sign, date, and write the time the sample was received on the same line. The sample can be relinquished to other qualified individuals in the same manner. Sample receipt in the laboratory is indicated by the Laboratory Director, Laboratory Master Technician or a Laboratory Technician accepting the sample and documenting it on the COC form. If the same individual transports the sample to the lab and processes that sample in the laboratory, then that person will record both accepting and relinquishing the sample on the COC form.

### 2.3.1 Sample Receiving and Storage

Samples must be delivered to the laboratory in coolers packed in ice less than six hours after sample collection. Analysis of the samples must begin within the stated hold times for each parameter from the time of sample collection. At the beginning of sampling, a sample bottle containing water should be placed in the cooler with ice, and then upon delivery of the cooler to the laboratory, the water in this bottle is measured to determine the sample receipt temperature.

Prior to accepting custody and signing for the samples, the laboratory representative verifies that all samples submitted are listed on the COC and that the COC documentation is complete. Received samples and corresponding documentation are carefully reviewed for compliance with regard to condition of containers, sample preservation and temperature (i.e., reading temperature of water blank in cooler), holding times (collection date/time), and accurate identification on the COC.

Once the COC has been verified against the delivered samples, sample information is entered into the laboratory receipt log. The receipt log for samples is kept as a Microsoft Excel spreadsheet. The file is password protected.

Samples received by the laboratory are identified by unique laboratory identification numbers. The sample's laboratory number is transcribed to each container associated with that sample using an indelible marker. Numbered samples are stored in secured areas according to aliquot preservation requirements.

At the end of the day or as soon as practical, the receipt log for all samples received on a day is printed and placed in a logbook in chronological order. The printed sheet(s) must be reviewed for correctness and then initialed at the bottom of the sheet. In the event an error is later found in the receipt log, the change must be made on all recording documents, electronic and hard copy, as applicable. Hard copy corrections must be made by drawing a single line through the error, writing the correct data above or to the side, and initialing and dating the entry.

### 2.3.2 Sample Distribution and Handling

Samples retrieved from their designated storage areas must be documented internally. Personnel removing samples from the storage areas are required to record the sample numbers removed, date, time, and their initials on the form. Staff must also document on that form the date and time samples are returned to storage. Several coolers and a refrigerator in the laboratory are for temporary storage of samples requiring refrigeration and awaiting preparation or analysis.

Notification of samples with parameters with critically short hold times (i.e., less than 48 hours) is provided verbally or in writing to the laboratory analytical staff on the day of receipt of such samples. Once notified, it is the responsibility of the analyst to perform the requested analysis within the appropriate hold time.

### 2.3.3 Sample Disposal

In general, samples are disposed of approx. 14 days after results have been reported to the client. Arrangements for shorter or longer storage times are made with client approval based on specific project requirements. All sample container labels are removed or obliterated prior to disposal. Destruction of samples are noted on internal COC forms.

All samples suspected to be bacterially hazardous, incubated samples, used media, and bacteria control samples are sterilized by autoclaving for 30 minutes at 121 °C. In general, other samples found to be hazardous, or RCRA "D" listed, is returned to the client for disposal. Other hazardous wastes are disposed of by the science building staff by sending directly to an in-state permitted landfill.

Sterilized and non-hazardous aqueous samples are disposed of by pouring the sterilized, neutralized, or non-hazardous sample into a conventional drain to the municipal sewage treatment system. Non-hazardous solid wastes (including emptied disposable containers from aqueous samples) are disposed of by placing in a dumpster for municipal landfill disposal. The date of sample disposal is recorded internally.

## 2.4 Analytical Methods

### 2.4.1 Control of Analytical Processes

All aspects of laboratory operations are controlled by key documents: quality assurance manual(s) and standard operating procedures (SOPs). The SOPs detail and document the procedures which implement the activities and requirements specified in the quality assurance manual.

To perform the tasks described in this QAPP, the laboratory uses 2 field and 2 laboratory analysis procedures:

- E. coli by IDEXX Colilert-24™ QuantiTray™ method , based on IDEXX 06-02027-18
- Total Suspended Solids (TSS) by gravimetric measurement, based on Method 2540 D of *Standard Methods*
- Dissolved oxygen by membrane electrode method, based on Method 4500-O G of *Standard Methods*
- Water temperature by thermometer or thermistor, based on Method 2550 B of *Standard Methods*

The step-by-step procedures of these techniques are provided in laboratory SOPs:

- SM 9223B (E. coli)
- SM 2540-D-2011 (Total Suspended Solids)
- SM 4500-0 G-2011 (field measurement of DO)

All laboratory SOPs referenced in this QAPP can be found on-site of the contracted laboratory at all times. Protocols are also in place, should issues occur in the laboratory. Appropriate corrective actions are outlined within each individual SOP, where applicable.

When samples are completely used or destroyed, a notation is made on the internal chain of custody.

Laboratory turnaround time is generally associated with meeting holding times for samples.

## 2.5 Quality Control (QC)

### 2.5.1 Dissemination of Quality Requirements

The laboratory uses several means of communication to ensure staff is informed of all quality requirements. Routine operational requirements are communicated to applicable staff through distribution of the QAPP and laboratory SOPs. All these documents are controlled internally and are issued to selected laboratory staff on an individual basis, depending on staff assignment, task responsibilities, and work location. The QAPP and all SOPs are available to all laboratory staff on the laboratory's computer network. Changes in requirements are communicated to laboratory staff by distribution of revisions to this QAPP and applicable SOPs.

Any laboratory staff member observing any occurrence (e.g., equipment failure) that impacts laboratory capabilities or schedule of deliverables (i.e., analysis results are to be reported to SC

DHEC and clients within 24 hours of completion of analysis) must immediately bring that observation to the attention of the Laboratory Director. The Laboratory Director shall immediately communicate the situation to the affected customer. A copy of this communication should be placed in the project file and the laboratory director can determine if any corrective actions are necessary.

Quality control (QC) procedures for laboratory measurements in this project are summarized in Tables 4-6. When recording results of QC measurements on samples (e.g., duplicate analysis), an acronym suffix is added to the sample number; the suffixes are as follows:

duplicate = D or DUP

replicates = R# or REP#

matrix spike = MS

matrix spike duplicate = MSD

Acronyms for recording other QC measurements are as follows:

blank = B or BLK

method blank = MB

calibration standard = CAL or CALIB

calibration verification standard = CV

initial calibration verification standard = ICV

primary standard = PS

working standard = WS

laboratory control sample = LCS

Temperature is measured with a thermometer in-situ conditions. For each cooler of samples that is transported to the analytical laboratory, a 100ml plastic container (prepared by the laboratory) will be included that is marked "temperature blank." This blank will be used by the laboratory's sample custodian to check the temperature of samples upon receipt to ensure that samples were maintained at the temperature appropriate for the particular analysis. Typically, a sample is collected in a 250 mL bottle with no preservative and the hold time is considered immediate. Temperature should be taken by a calibrated NIST thermometer.

Table 4. Summary of QC requirements for E. coli analysis by Colilert-24

| QC Sample or Activity | Minimum Frequency | Acceptance Criteria | Corrective Action |
|---|---|---|---|
| Capability demonstration | Four (4) prepared samples analyzed prior to any customer sample analyses | Criteria for LCS recovery and duplicate precision | Repeat until acceptable |
| Media sterility check | Prior to use of new lot of Colilert-24 and weekly | No fluorescence | Investigate problem. Eliminate contaminations. Obtain new lot of Colilert-24,if necessary. Repeat until successful before using Colilert-18 lot. |
| Media positive check with control culture | Prior to use of new lot of Colilert-24 and weekly | Fluorescence | Investigate problem. Obtain new lot of Colilert-24 if necessary. Repeat until successful before using Colilert-18 lot. |
| Media negative checks with control cultures (gram+ and gram-) | Prior to use of new lot of Colilert-24 | No fluorescence | Investigate problem. Eliminate contaminations. Obtain new lot of Colilert-24 if necessary. Repeat until successful before using Colilert-18 lot. |
| Method blank | At least weekly, prior to sample analysis | ≤ 20 CFU/100 mL | Clean analytical system and repeat MB analysis. Identify and eliminate source of contamination. |
| Sample duplicate or matrix spike duplicate | At least one (1) weekly, and one with all large sample batches (~20 samples) | RPD ≤ 200% for <150 CFU/100 mL<br>RPD ≤ 100% for ≥ 150 CFU/100 mL | Investigate problem. If system precision is in control, qualify results. If system precision is out of control, reanalyze entire batch. |
| Internal PE sample | Samples and frequency determined by Lab QA Officer | Criteria for LCS recovery and duplicate precision | Investigate all unacceptable results. |
| Blind PE sample | Samples and frequency determined by accrediting agencies and projects | Determined by PE provider | Investigate all unacceptable results. |

LCS = laboratory control sample
QC = quality control
MB = method blank
%R = percent recovery
MDL = method detection limit
RL = reporting limit
PE = performance evaluation
RPD = relative percent difference

Table 5. Summary of QC requirements for TSS

| QC Sample or Activity | Minimum Frequency | Acceptance Criteria | Corrective Action |
|---|---|---|---|
| Capability demonstration | Four (4) prepared samples analyzed prior to any customer sample analyses | 90 – 110% R<br>< 10% RSD | Repeat until acceptable |
| Balance Calibration Check | Prior to weighing any sample filters | Weight of certified 200 mg weight: 0.1998 – 0.2002 g | Investigate problem including cleaning weight and balance. If balance is out of calibration attempt recalibration or use another balance until obtain acceptable calibration check. |
| Method Blank | At least one (1) per analysis batch of up to 10 samples | For 1.0 L blank filtered: < 1.0 mg/L | Investigate, identify, and correct the problem. If system accuracy is in control, qualify results. If system accuracy is out of control, correct problem before analyzing samples |
| Sample analysis | For all sample analyses | Total residue on filter:<br>≥2.5 mg to ≤ 200 mg | If total residue on filter < 2.5 mg report result as < RL<br>If total residue on filter > 200 mg filter a smaller volume of sample. |
| Laboratory Control Sample | At least one (1) per year | 90 – 110% R | Investigate, identify, and correct problem. If system accuracy is in control, qualify results. If system accuracy is out of control, correct problem before analyzing samples. |
| Sample duplicate | One (1) per preparation batch of up to 10 samples | RPD ≤ 5% | Investigate problem. If system precision is in control, qualify results. If system precision is out of control, reanalyze entire batch. |
| Internal PE sample | Samples and frequency determined by Lab QA Officer | Criteria for LCS recovery and duplicate precision | Investigate all unacceptable results. |
| Blind PE sample | Samples and frequency determined by accrediting agencies and projects | Determined by PE provider | Investigate all unacceptable results. |

LCS = laboratory control sample
MB = method blank
MDL = method detection limit
MS = matrix spike
PE = performance evaluation
QC = quality control
%R = percent recovery
RL = reporting limit where RL = (2.5 mg /mL filtered) x 1000 mL
RPD = relative percent difference
RSD = relative standard deviation

Table 6. Summary of QC requirements for YSI Pro Plus probes

| QC Sample or Activity | Minimum Frequency | Acceptance Criteria | Corrective Action |
|---|---|---|---|
| Capability demonstration | Four (4) prepared samples analyzed prior to any customer sample analyses | DO 97-104% of theoretical DO<br>Others 75-125% R<br>Others RPD ≤ 25% | Repeat until acceptable. |
| Calibration stability monitoring | Immediately before calibration measure standards | Not applicable. | Not applicable. Results are used to monitor stability of probes and evaluate need for maintenance. |
| Calibration | Daily prior to sample analysis and after every 8 hours | After calibration, measure calibration standards (conductivity, pH, DO % saturation of water saturated air) as sample<br>pH ± 0.1 of expected, others 99-101% R | Investigate and fix any obvious problems. Repeat until acceptable. |
| Calibration check | Immediately following calibration | Measurement of calibration standards or LCS (conductivity, pH, DO % saturation of LCS or of water saturated air)<br>Cond. 90-110% R, pH ± 0.1 of expected, DO 97-104% sat<br>****DO method requires LCS to be read in duplicate with each calib. event**** | Investigate and fix any obvious problems. Recalibrate and repeat until acceptable. |
| Field duplicate (duplicate sample collected at one of sampling sites | One (1) per sampling event | RPD ≤ 25% | Investigate problem. If system precision is in control, qualify results. If system precision is out of control, reanalyze all sampling sites if possible. |
| Internal PE sample | Samples and frequency determined by Lab QA Officer | 75-125% R<br>RPD ≤ 25% | Investigate all unacceptable results. |
| Blind PE sample | Samples and frequency determined by accrediting agencies and projects | Determined by PE provider | Investigate all unacceptable results. |

# 3. Data Validation and Usability

### 3.1.1. Validation and Verification Methods

All data receive analyst review and independent analyst or peer review. The Laboratory Director and/or quality assurance personnel will review the data to varying degrees at different points in the review process. These review processes are appropriately documented before data are released from the laboratory.

*Data review* ensures that raw data are properly collected, reduced, and reported. *Data verification* confirms by examination of the measurement process and provision of evidence, that specified method, procedural, or contractual requirements have been met. For example, QC measurements must indicate that deviations between measured values and known values are smaller than the maximum allowable error (i.e., DQIs).

*Data validation* is the process of substantiating that specified performance criteria were achieved for an entire data set or data reporting group, including comparisons between analytes and samples to see if relationships are scientifically reasonable.

| tem | Criteria | If not met sample is accepted, flagged or rejected? | Flag | Comments |
|---|---|---|---|---|
| Sample not analyzed within hold time | Sample received in the lab within 6 hours of collection and analyzed within 2 hours of receipt appropriate hold time | Rejected | HT | Out of holding time |
| Lost sample | Proper COC documentation not followed and sample is misplaced | (Unable to analyze) | LS | N/A |
| Unable to Collect Sample | Various circumstances (i.e., weather, lost sampling container) cause sample to not be collected | (Unable to analyze) | NS | N/A |
| Sample not held within required temperature range | Temperature blank within cooler indicates temperature above 6° C or proper storage equipment failed to read within range (refrigerator/freezer) | Rejected | T | Out of required temperature range |
| Temperature blank not placed within cooler during sample transport | Unknown receipt temperature | Flagged | UT | Noted |
| Incorrect sampling container used for sample collection | Incorrect sampling container used for sample collection | Flagged | SC | Noted |
| Improper preservation | Improper preservation (i.e., acidification, filtering) | Flagged | IP | Noted |

**Table 7: Criteria for accepting, rejecting, or flagging data**