VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER MONITORING AND ASSESSMENT PROGRAM

AMBIENT WATER QUALITY MONITORING PROJECT PLAN

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1.0 PROGRAM MANAGEMENT

1.1 Approval Sheet

Concurrence

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Note: This approval action represents EPA's determination that the document(s) under review comply with applicable requirements of the EPA Region 3 Quality Management Plan [https://www.epa.gov/sites/production/files/2020-06/documents/r3qmp-final-r3-signatures-2020.pdf] and other applicable requirements in EPA quality regulations and policies [https://www.epa.gov/quality]. This approval action does **not** represent EPA's verification of the accuracy or completeness of document(s) under review and is **not** intended to constitute EPA direction of work by contractors, grantees or subgrantees, or other non-EPA parties.

Revision History

This table shows changes to this controlled document over time. The most recent version is presented in the top row of the table. Previous versions of the document are maintained by Quality Manager.

EPA Document Control #	DEQ Revision #	History/ Changes	Effective Date
EPA DCN: 200198.2	08	1. Updated method: EPA 6020A to EPA 6020B 2. Mercury in fish tissue: updated SW-846 3052/6020A/1631 to SW-846 3052/6020B/7471B 3. Sediment mercury: updated EPA 3051B (digestion), EPA 245.1,SW7471B to SW846 3051A (digestion),User Defined EPA 245.1 4. Removed DEQ tracking table (formerly section 1.4) to remove redundancy with this revision history table	3/11/2022
	09	1. Updated calibration schedule. See section 2.7.1 and Table 12. Mid-week calibrations for pH and specific conductance dependent on previous day post-check. Previously calibrated daily. 2. Added benthic algae parameters from filamentous algae monitoring program. Sample and parameter details added to Tables 2, 5, and 6, and Appendix C.	

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1.4 PROJECT ORGANIZATION

Figures 1 and 2 depict the organizational structures of the Virginia Department of Environmental Quality (DEQ) and Division of Consolidated Laboratory Services (DCLS) for the Water Quality Monitoring (WQM) program. The associated responsibilities for DEQ and DCLS personnel for the program are as follows:

DEQ Regional Field Staff:

- Perform all field activities including field measurements, observations and sampling in accordance with the most recently approved Quality Assurance Project Plan (QAPP) and Standard Operating Procedures (SOPs).
- Notify immediate supervisors and WQM QA Coordinator of any issues encountered.

DEQ Regional Program Planners:

- Manage regional day to day operations of the Ambient Water Monitoring Project.
- Supervise regional conductance of the project in accordance with the project plan.
- Coordinate routine WQM program activities.
- Provide input and implement Regional Program Manager's recommendations regarding program development, conductance, and overall program management.

DEQ Regional Program Managers:

- Make recommendations for corrective action as requested by regional personnel.
- Assure that activities in the regions meet the requirements of the program as outlined in this project plan.
- Provide recommendations regarding the development, implementation and overall management of the program.

DEQ Laboratory Liaison:

- Coordinates program activities between the Regional Office staff and DCLS including sample collection scheduling based on laboratory capabilities.

DEQ Quality Assurance Coordinator:

- Revises and updates the existing Quality Management Plan, Quality Assurance Project Plan and Standard Operating Procedures Manual to ensure that approved practices and procedures are available for use by program personnel.
- Coordinates QA activities among contracted laboratories to ensure quality in analytical results and data validity. When necessary, monitors laboratory performance using a blind check sample program and performs inspections and recommends corrective actions when necessary.
- Presents training in field sampling and measurements; conducts/ coordinates agency audits of the program; reports to management on the quality assurance aspects of the program and where appropriate, makes recommendations for corrective action.

DEQ Monitoring Coordinator:

- Implements the project plan and manages the Commonwealth's water quality monitoring strategy through the formal establishment of program policy, objectives, priorities and methodologies.
- Participates in specialized intensive scientific studies in water quality, seeking improved technologies and methodologies in the detection and quantification of environmental pollutants.

DEQ WMA Data Manager:

- Responsible for the overall strategy and functioning of the monitoring program.
- Assists in the duties of supporting staff including QA Coordinator and Monitoring Coordinator and by facilitating cooperation of planning and program managers at Regional Offices throughout the state.
- Performs all aspects of data management, including tracking, compilation, and review of data entry. Identify and corrects errors and ensures automated uploads of data to database are completed as scheduled.

DEQ WQM Program Managers:

- Assure that activities in the regions meet the requirements of the program as defined in this project plan.
- Provide recommendations regarding the development, implementation, and overall management of the program.

DCLS Laboratory Managers:

- Manage the laboratory departments performing analyses on samples taken as part of the WQM program.
- Responsible for oversight of all analytical activities and to ensure all activities are performed during laboratory analysis are in accordance with the DCLS Quality Manual.

DCLS QA Officer:

- Responsible for establishing, implementing, and coordinating a comprehensive QA/QC program for analyses and ensuring that the analytical operations producing environmental data are of sufficient quality to meet or exceed requirements for informed decision making.

Figure 1: DEQ Organizational Chart for WMA Program Network

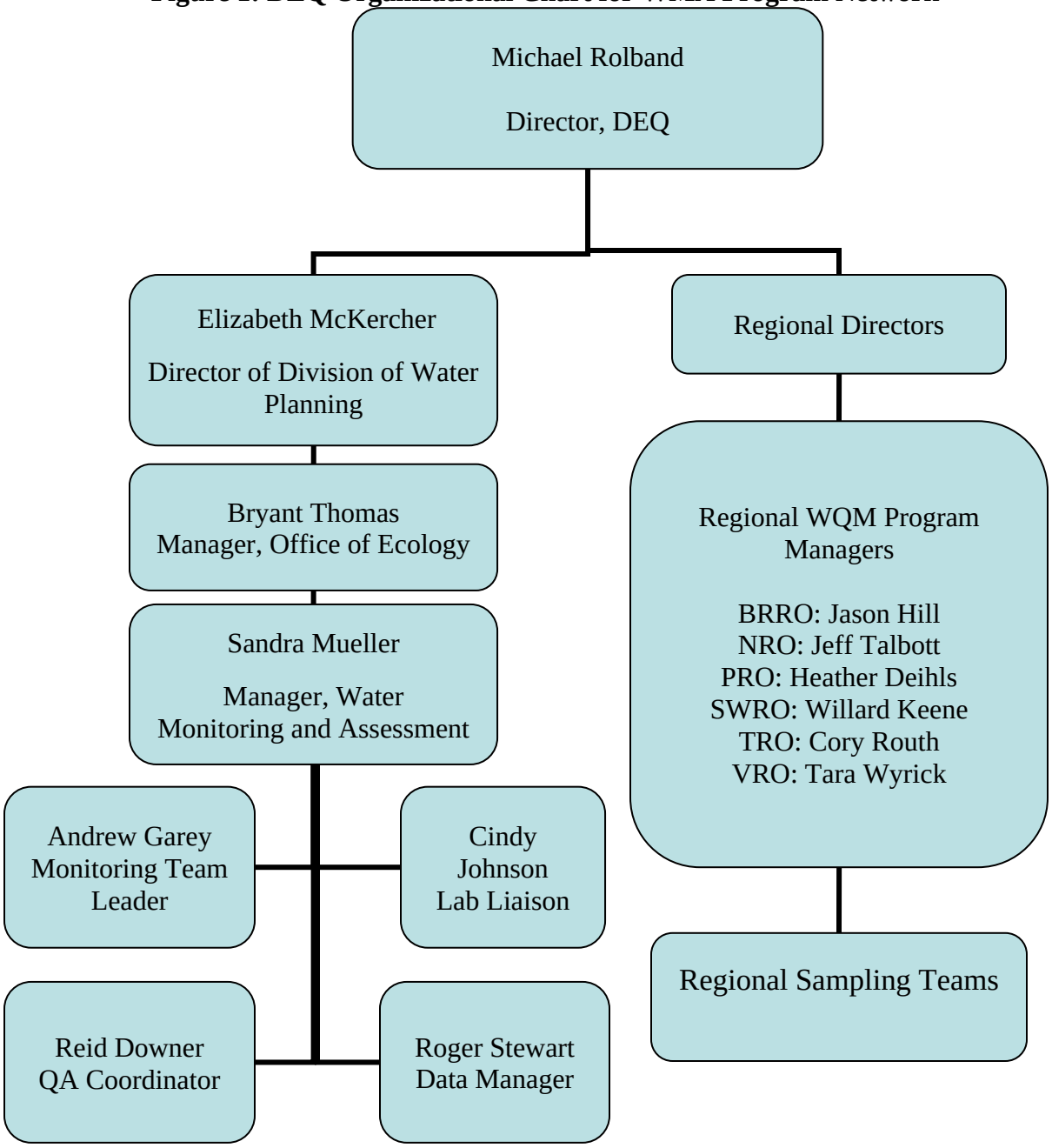
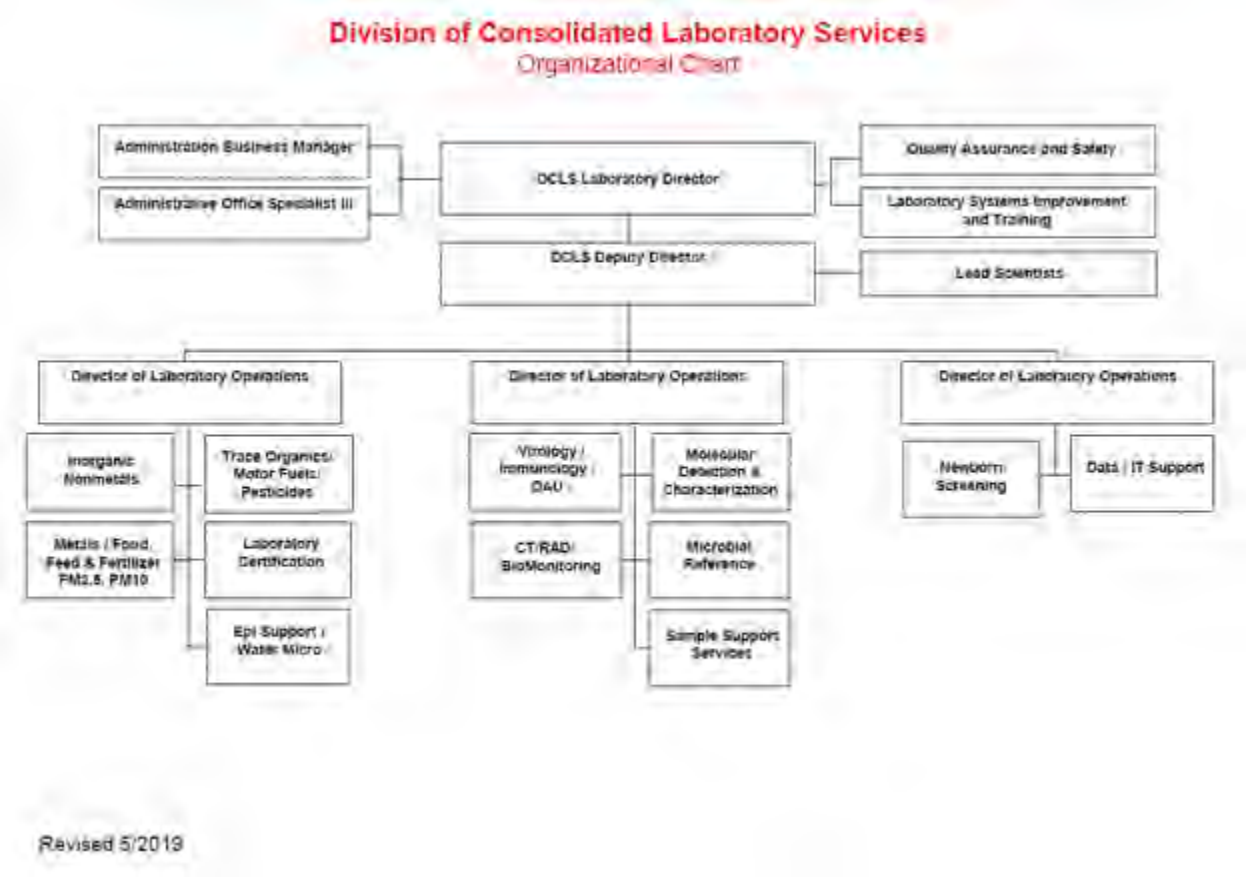


Figure 2: DCLS Organizational Chart



1.5 Problem Definition/Background

Funding agreements between Virginia and the Environmental Protection Agency (EPA) require Virginia to monitor the Commonwealth's waters and report the results to the EPA to support the goals of the Clean Water Act.

In Virginia Code, the "Water Quality Monitoring, Information and Restoration Act" ("WQMIRA; VAC Chapter 3.1 of Title 62.1 Article 4.1 62.1-44.19:4 through 62.1-44.19:8) requires monitoring and comprehensive assessment of the quality of the state's surface waters. WQMIRA ushered in a new era for DEQ's water quality monitoring efforts by identifying specific areas needing improvements to meet the growing needs of the commonwealth. Areas targeted for improvement included providing consistency in monitoring methods, the evaluation of water quality trends, the distribution and abundance of toxics, sampling frequency, and the expansion of geographic coverage to include all state waters. Additionally intergovernmental agreements are consistently demanding more of our monitoring

programs, including the development of Total Maximum Daily Loads (TMDLs) for those stream segments identified as impaired in biennial 303(d) reports. These changes, along with WQMIRA, mark a shift in emphasis that extends beyond monitoring to include the characterization and resolution of problems found during the monitoring efforts.

The ultimate goal of the WQM program is to provide accurate data that will permit the evaluation, restoration and maintenance of the quality of the Commonwealth's waters at a level that provides for multiple uses as prescribed by Federal and State laws.

In order to achieve this goal, and to satisfy scientific, legislative, and aesthetic requirements related to the quality of the Commonwealth's water resources, DEQ has established a series of specific objectives to identify and define the diverse functions of WQM program. Many of these specific objectives are directly related to the following five general objectives set forth in the Clean Water Act.

1. Determination of water quality standards attainment (section 305(b)) (for specifics on Virginia's water quality standards refer to https://law.lis.virginia.gov/admincode/title9/agency25/chapter260/).
2. Identification of impaired waters (section 303(d)) (for assessment procedures refer to https://www.deq.virginia.gov/our-programs/water/water-quality/assessments/wqa-guidance-manual).
3. Identification of causes and sources of water quality problems (sections 305(b) and 303(d)).
4. Support for implementation of water management programs (sections 303, 314, 319, 402 etc.)
5. Support for the evaluation of program effectiveness (sections 303, 402, 314, 319 etc.)

To attain the overall goal of the agency's WQM program and the general objectives of the Clean Water Act, below are specific objectives of the WQM program:

1. Provide accurate, representative data for water quality characterization and assessment of all surface water statewide.
2. Establish consistent statewide parameter selection and monitoring techniques, in order to ensure data reliability and comparability throughout the agency.
3. Assure that frequency of sampling and the total number of observations collected are sufficient to provide adequate data using statistically based and scientifically defensible assessment procedures.
4. Wherever possible and as available resources permit, assure flow rates are determined simultaneously with the collection of water quality data.
5. Monitor, according to a plan and schedule, all substances that are discharged into Commonwealth waters subject to Virginia Water Quality Standards or otherwise necessary to determine water quality conditions.
6. Continually evaluate the overall success of Commonwealth's water quality monitoring and management efforts.

7. Provide adequate data and analytical procedures for short, medium and long-term statistical evaluations of water quality variation and trends within identifiable geographic or hydrologic defined water bodies.

Virginia Code 9VAC25-260-10 A. defines designated uses as applicable to all state waters, including wetlands as follows: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish.

Virginia Code 9VAC25-260-10 also lists additional sub uses for Chesapeake Bay for Migratory Fish and Spawning nurseries, Shallow Water Submerged Aquatic Vegetation acreage, Open Water Aquatic Life, Deep Water Aquatic Life and Deep Channel Seasonal Refuge. Many of the assessments for these data are performed outside of DEQ through contractual agreements (Virginia Institute of Marine Science and Old Dominion University) or under the Federal-multistate Chesapeake Bay Program Agreement. The results are then included in the 305b/303d assessment of Virginia waters.

The objective of assessment is to determine whether waters are fully supporting or impaired for the designated uses of an assessment unit (AU) A 10.5% exceedance threshold is set for determining full support or impairment for conventional parameters (i.e., dissolved oxygen, pH, and temperature). An exceedance rate that is greater than 10.5% with at least 2 exceedances is considered impaired. This percentage rule is governed by the fact that sampling is associated with unknown equipment and human error, as well as an acknowledgment that designated uses are not impacted by infrequent, short-term exceedances of water quality standards.

1.6 Project/Task Description and Schedule

1.6.1 Work to Be Performed

Each year, the DEQ WQM program monitors water quality conditions at over 800 locations. Most of the stations in the non-coastal regions are accessed by land via bridge crossings or other public access points. Estuaries and other large waterbodies are usually monitored by boat. When boat sampling is not feasible, estuary sampling is conducted off a dock or bridge to sample away from the shoreline.

The WQM program focuses primarily on the chemical, physical, and bacterial pathogen characteristics of the water column. Indicators are primarily select chemicals that have current state water quality standards and can be cost-effectively analyzed. Additional indicators may also be included that do not have specific associated standards but are considered useful for interpretation of other measurements such as identifying long-term trends.

A basic suite of core parameters is routinely measured at all stations. Parameters may be added or removed depending on site specific concerns such as stream classification, discharge types

and historical or suspected issues. Field observations of weather conditions are also recorded at all sites.

Core indicators are listed in Table 1.

Table 1: Core Water Quality Monitoring Indicators

Watershed Station	Trend Station
Temperature, pH, specific conductance, salinity (when appropriate), dissolved oxygen, total nitrogen, total phosphorus	Temperature, pH, specific conductance, salinity (when appropriate), dissolved oxygen, total Kjeldahl nitrogen, total nitrogen, total phosphorous, total suspended solids, chlorophyll a (tidal), salinity (tidal), hardness (non-tidal), Fecal Coliform, E. coli or Enterococcus

1.6.2 Work Schedule

The trend program is geared towards collection of long-term data and is therefore a continuous program of indeterminate duration. The watershed program consists of sampling all of Virginia's watersheds on a continuing rotational basis, such that when one watershed is completed another is started. Watershed stations are typically visited monthly year-round for collection of field measurement and analytical samples. Collection for the watershed program will also continue indefinitely. Designated monitoring field staff in each Regional Office performs sampling for both programs. When staff shortages and/or position vacancies occur, trained volunteers and interns may conduct the sampling.

Individual field staff determines their specific daily sampling schedule. Flexibility in scheduling site visits is needed to allow field staff to balance their workloads, reschedule for inclement weather, and allow for equipment availability. Field staff makes every effort to complete all work as scheduled.

The WQM program is an on-going program requiring sample collection and analysis throughout the year. Data produced for the program are reviewed quarterly for QA/QC purposes to ensure data are valid when assessed for 305(b) designations every 2 years.

Because the WQM budget is dependent upon available state resources, DEQ has set up a priority scale for the various water quality monitoring efforts conducted by the regions. Trend stations are considered priority 1 indicating the sites will be monitored even in times of limited resources to prevent the possibility of data gaps.

Watershed stations are designated as priority 2 allowing limited flexibility in the sampling protocol. Under priority 2 conditions, the frequency of sample collection may not change, but the number of sampling sites on a given watershed may decrease during times of limited resources. If the number of sites is reduced, the number and positioning of the remaining sites sampled must still be able to adequately describe ambient conditions of a watershed.

1.7 Quality Objectives and Criteria for Measurement Data

1.7.1 Data Quality Objectives

Data Quality Objectives (DQOs) are qualitative and quantitative statements that specify the quality of data required to support specific WQM decisions. DQOs also specify the level of uncertainty that a decision maker is willing to accept in results derived from monitoring data that are used for a regulatory or programmatic decision, such as establishing analytical method requirements, establishing sampling protocols or the revision or development of industry standards.

The WQM program, using existing performance information on the methods and procedures contained in this document, developed the DQOs defined in this section. Because DQOs are established through an iterative process, these values may be adjusted by the WQM QA Coordinator based on continual evaluation of performance data generated by this program.

The main objective of this document is to provide monitoring data of known and documented quality for the purpose of:

1. Analyzing trends in water quality and comparisons with water quality standards.
2. Evaluating of the effectiveness of implementation of best management practices (BMPs).
3. Performing water quality assessments in the biennial water quality inventory report (the 305(b) report) to EPA.
4. Stream segment rankings (303(d) listing).
5. Providing data and guidance to managers and modelers for restoration programs.

The DQOs for this program are provided in Table 2.

1.7.2 Action Limits/Levels

The quality of data generated by various sampling activities can be expressed in terms of comparability, representativeness, precision, bias, and completeness using the following criteria.

- **Comparability**
  Comparability refers to the extent to which the data generated by this program is comparable to other studies conducted in the past or from other areas. To ensure comparability, DEQ requires the use of standardized sampling and analytical methods, uniform units of reporting, and standardized site selection procedures. The comparability of laboratory data produced for the DEQ WQM by DCLS and other contracted laboratories is ensured by using, where possible, EPA approved analytical methods, Standard Methods, USGS Methods, or documented modifications thereof which have been documented to produce equal or better results. These methods have specified units in which the results are to be reported.

- **Representativeness**

The representativeness of the data is mainly dependent on establishment of sampling locations and sampling procedures that produce results representative of the true conditions at the time of sampling. The goal for meeting total representation of the site is limited by the types and number of potential sampling points, the media being sampled and the availability of funding.

Water flowing past a given location on land is constantly changing due to a variety of factors including response to inflow, tidal cycle, weather, etc. Wherever possible and applicable, sampling schedules and collection methodologies will be designed with respect to frequency and sampling locations to maximize the representativeness of each site. However, when collecting bed sediment samples, the sampling design focuses on the collection of fine, recently deposited sediment, which can introduce a built-in bias that may not be thoroughly representative of the typical bed sediment within a particular sampling site.

- **Precision and Bias**
  The precision and bias of data are influenced by the procedures used by the analytical laboratory and field staff during the collection and analysis of a sample. Data precision is a measure of the reproducibility of the measurement when the sample collection and analysis is repeated. It is usually reported in Relative Percent Difference (RPD). The bias of an analysis is a measure of how much of a constituent actually present is determined. It is typically measured, by adding a known amount of a constituent to a sample and determining how much of the added constituent (spike) is then measured. This spike analysis is reported as Percent Recovery. Acceptable RPDs and percent recoveries depend on many factors including: the laboratory and analytical method used, the constituent measured and the media of sample.

- **Completeness**
  The completeness of data is the relationship of how much data are available for use for its intended purpose as compared to the total data collected. Ideally, 100% of the data should be available for its intended use. However, there is always the possibility of data loss due to laboratory or equipment error, insufficient sample volume, or samples broken during shipment. In addition, unexpected situations may arise where field conditions do not allow for 100% data completeness. Due to these unforeseen possibilities, WQM considerers 90% data completeness sufficient to generate meaningful data.

- **Sensitivity**
  Sensitivity is defined as the ability of the method or instrument to discriminate between measurement responses. For this program, WQM and state laboratory personnel employ the most sensitive method and instruments possible to analyze the samples.

- **Method Detection Limits (MDL)**
  In general, an MDL is the smallest amount of analyte that can be detected above signal noise and is within specified confidence levels. MDLs are calculated in the laboratory by analyzing a minimum of seven low level standard solutions using the procedures in the Federal Register, 40 CFR Part 136 Appendix B (Revision 1.11).

Table 2: Data Quality Objectives for Non-metal Analyses and Field Parameters

Analyte	Matrix	MDL*	Units	Accuracy Goal	Precision Goal
Temperature	Water	NA	°C	0.2	±10%
Depth	Water	NA	Meters	0.3	±15%
pH	Water	NA	SU	0.2	±5%
DO	Water	NA	mg/L	0.2	±5%
Specific conductance	Water	NA	µS/cm	1% of range	±10%
Turbidity	Water	NA	NTU	5% of range	±10%
Alkalinity	Water	1.0	mg/L	10%	±20%
Ammonia Nitrogen	Water	0.003	mg/L	10%	±20%
Ash free dry mass, benthic	Water	0.0005	g/m^2		
BOD	Water	2	mg/L	10%	±20%
Chloride	Water	0.02	mg/L	10%	±20%
Chlorophyll a	Water	0.1	µg/L	20%	±30%
Chlorophyll a, benthic	Water	15	mg/m^2		
Chlorophyll b, benthic	Water	15	mg/m^2		
COD	Water	1	mg/L	10%	±20%
E. Coli	Water	1.1	org/100 ml	N/A	N/A
Enterococcus	Water	2	org/100 ml	N/A	N/A
Fecal Coliform	Water	1	org/100 ml	N/A	N/A
Hardness	Water	0.25	mg/L	10%	±20%
Nitrate-Nitrite-N	Water	0.002	mg/L	10%	±20%
Orthophosphate-P	Water	0.002	mg/L	10%	±20%
Pheophytin a, benthic	Water	15	mg/m^2		
Sulfate	Water	0.3	mg/L	10%	±20%
Tannin/Lignin	Water	0.106	mg/L	10%	±20%
Total Kjeldahl Nitrogen	Water	0.03	mg/L	10%	±20%
Total Nitrogen	Water	0.03	mg/L	10%	±20%
Total Organic Carbon	Water	2.6	mg/L	10%	±20%
Total Phosphorus	Water	0.005	mg/L	10%	±20%
TSS	Water	1.17	mg/L	10%	±30%

* MDL values are in reference to methods with the lowest acceptable MDL found in the 2015 DCLS laboratory catalog. Certain parameters may have higher MDL values if using a different test method.

Table 3: Data Quality Objectives for Metal Analyses

Analyte	Matrix	MDL*	Units	Accuracy Goal	Precision Goal
Aluminum,dis.	Water	0.02	µg/L	±30%	±20%
Antimony, dis.	Water	0.02	µg/L	±30%	±20%
Arsenic, dis.	Water	0.05	µg/L	±30%	±20%
Beryllium, dis.	Water	0.05	µg/L	±30%	±20%
Bromide, dis.	Water	0.02	µg/L	±30%	±20%
Cadmium, dis.	Water	0.04	µg/L	±30%	±20%
Calcium, dis.	Water	0.02	µg/L	±30%	±20%
Chromium, dis.	Water	0.03	µg/L	±30%	±20%
Copper, dis.	Water	0.02	µg/L	±30%	±20%
Iron(ICP), dis.	Water	10	µg/L	±30%	±20%
Lead, dis.	Water	0.02	µg/L	±30%	±20%
Magnesium(ICP), dis.	Water	0.02	µg/L	±30%	±20%
Manganese, dis.	Water	0.04	µg/L	±30%	±20%
Mercury, dis.	Water	0.3	µg/L	±30%	±20%
Nickel, dis.	Water	0.01	µg/L	±30%	±20%
Potassium	Water	0.02	µg/L	±30%	±20%
Selenium, dis.	Water	0.03	µg/L	±30%	±20%
Silver, dis.	Water	0.02	µg/L	±30%	±20%
Strontium, dis.	Water	0.02	µg/L	±30%	±20%
Thallium, dis.	Water	0.01	µg/L	±30%	±20%
Uranium	Water	0.05	µg/L	±30%	±20%
Vanadium, dis.	Water	0.02	µg/L	±30%	±20%
Zinc, dis.	Water	0.2	µg/L	±30%	±20%
Aluminum	Sediment	70	mg/kg	±30%	±20%
Antimony	Sediment	0.07	mg/kg	±30%	±20%
Arsenic	Sediment	1	mg/kg	±30%	±20%
Beryllium	Sediment	1	mg/kg	±30%	±20%
Cadmium	Sediment	0.05	mg/kg	±30%	±20%
Chromium	Sediment	4	mg/kg	±30%	±20%
Copper	Sediment	0.4	mg/kg	±30%	±20%
Iron	Sediment	100	mg/kg	±30%	±20%
Lead	Sediment	0.3	mg/kg	±30%	±20%
Lithium	Sediment	0.2	mg/kg	±30%	±20%
Manganese	Sediment	2	mg/kg	±30%	±20%
Mercury	Sediment	0.03	mg/kg	±30%	±20%
Nickel	Sediment	0.4	mg/kg	±30%	±20%
Selenium	Sediment	0.4	mg/kg	±30%	±20%
Silver	Sediment	0.2	mg/kg	±30%	±20%
Thallium	Sediment	0.05	mg/kg	±30%	±20%
Vanadium	Sediment	0.03	mg/kg	±30%	±20%
Zinc	Sediment	7	mg/kg	±30%	±20%
Aluminum	Fish Tissue	0.5	mg/kg	±25%	±20%
Antimony	Fish Tissue	0.05	mg/kg	±25%	±20%
Arsenic	Fish Tissue	0.05	mg/kg	±25%	±20%
Barium	Fish Tissue	0.03	mg/kg	±25%	±20%
Beryllium	Fish Tissue	0.01	mg/kg	±25%	±20%
Cadmium	Fish Tissue	0.03	mg/kg	±25%	±20%
Chromium	Fish Tissue	0.03	mg/kg	±25%	±20%
Copper	Fish Tissue	0.05	mg/kg	±25%	±20%
Lead	Fish Tissue	0.06	mg/kg	±25%	±20%
Manganese	Fish Tissue	0.07	mg/kg	±25%	±20%

Mercury	Fish Tissue	0.01	mg/kg	±25%	±20%
Nickel	Fish Tissue	0.04	mg/kg	±25%	±20%
Selenium	Fish Tissue	0.07	mg/kg	±25%	±20%
Silver	Fish Tissue	0.09	mg/kg	±25%	±20%
Thallium	Fish Tissue	0.07	mg/kg	±25%	±20%
Vanadium	Fish Tissue	0.13	mg/kg	±25%	±20%
Zinc	Fish Tissue	0.2	mg/kg	±25%	±20%

* MDL values are in reference to methods with the lowest acceptable MDL found in the 2016 DCLS laboratory catalog. Certain parameters may have higher MDL values if using a different test method.

Table 4: Data Quality Objectives for Organic Analyses

Analyte	Matrix	MDL*	Units	Accuracy Goal	Precision Goal
Particle size	Sediment	N/A	%	N/A	20%
Semi Volatile Organic Acid	Water	2	µg/L	±30%	±20%
Semi Volatile Organic BN	Water	0.4	µg/L	±30%	±20%
Total organic carbon	Sediment	1	g/kg	N/A	20%
Volatile Organic Compounds	Water	0.2	µg/L	±30%	±20%

* MDL values are in reference to methods with the lowest acceptable MDL found in the 2016 DCLS laboratory catalog. Certain parameters may have higher MDL values if using a different test method.

1.8 Special Training Requirements/Certifications

1.8.1 Field Personnel Training

Proper training of field personnel represents a critical aspect of quality control. Field technicians are trained to conduct a wide variety of activities using standardized protocols to ensure comparability in data collection among field teams and across geographic regions.

Entry level training is provided for new employees to ensure quality-related qualifications in field methods (such as instrument operation, approved sample collection, preservation, handling, field testing, and quality assurance procedures) and in computer skills such as station establishment, sample scheduling and data entry and retrieval. Training in field methods is provided by the WQM Quality Assurance Coordinator and experienced regional personnel. A team of Central Office personnel consisting of the WMA Data Manager and other qualified personnel provides computer training.

All staff collecting water quality samples is required to complete formal training and/or testing modules on the procedures outlined in the most recent edition of the WQM SOP. New staff must complete training and pass testing within 12 months after hire or before collecting chain of custody samples, whichever comes first. Staff who are already certified must be recertified via retesting every two years.

Staff who fail to pass the certification test must discontinue sampling and be retrained and pass the test before resuming sampling. New hires that do not successfully complete training will be paired with a certified sampling partner until they are able to successfully complete the test.

Training materials include the use of PowerPoint presentations and other visual and written training resources along with hands on training. Course content includes all portions of the most recent edition of the WQM SOP as well as the use of the water monitoring module of the agency database (CEDS) and chain of custody procedures.

When a boat is required for sample collection activities, the vessel operator must be an experienced boat handler and have completed the appropriate boating safety courses for the size class of vessels being utilized, as well as be well-versed in navigational skills and proficient in the use of GPS equipment. The vessel itself shall contain all the required U.S. Coast Guard approved safety gear, possess current state registration, and be in good operational condition. Field staff assigned to work on a boat must pass a course in basic boat operations recognized by the United States Coast Guard or Virginia Game and Inland Fisheries.

Each field team member receives training to enable compliance with all applicable Occupational Safety and Health Administration or equivalent state or local regulation requirements including proper handling and disposal of routinely used chemicals.

1.8.2 Continued Proficiency of Field Personnel

To ensure continued proficiency in Quality Assurance/Quality Control procedures, the agency Quality Assurance Coordinator, or designee, performs a field audit of staff collecting samples. All field staff undergoes an audit at least once every two years. Staff performing monitoring for more than one type of program using significantly different protocols (example: riverine ambient and lake monitoring) may be audited more frequently.

1.8.3 Laboratory Personnel Training

A written description for each job position in the laboratory is kept on record within the laboratory division. The position descriptions include the knowledge, skills, abilities and duties required of the position. A performance plan is prepared annually for each employee and their performance is evaluated by one interim and one final evaluation. Training is conducted at the division and group level. Performance evaluation samples are routinely used to determine proficiency in an area. It is the responsibility of the group manager to ensure orientation and rotation of workstation schedules. The division maintains a training record documenting each employee's credentials regarding education, seminars, workshops and on-site training. In order to assure competency and the ability to work independently, each employee is required to demonstrate completion of the following requirements:

1. Instruction in or prior knowledge of sample preparation, analysis and instrumentation principal associated with the method.
2. Instruction on the principles of laboratory safety associated with the method including review of associated MSDS forms.
3. Has read and understands the methods and SOPs associated with the analyses.
4. Instruction in or has prior knowledge of the instrument for the method.

5. Demonstrated performance of the method under the direct supervision of the trainer.
6. Instruction in or has prior knowledge of instrument and computer maintenance.
7. Independent successful completion of demonstration of capability.
8. Independent analysis of three sets of samples.

1.9 Documentation and Records

1.9.1 QA Project Plan Distribution

This QAPP will be distributed to each Regional Office and contract lab responsible for the collection of samples and generation of analytical data. The WQM QA Coordinator will be responsible for ensuring that any necessary changes required to keep the QAPP up to date with actual practices are documented and implemented. The QA Coordinator is also responsible for ensuring that a distribution list of QAPP recipients is maintained, such that revisions and updates can be distributed. The document control format used in this QAPP will identify the QAPP revision number and revision data. A QAPP revision history will be maintained that identifies each revision and changes to the program throughout its implementation.

The QAPP shall be reviewed at least annually to ensure that the project will achieve all intended purposes. Project managers, QA staff and other applicable personnel shall participate in the review of the QAPP. In addition, it is expected that from time to time ongoing and perhaps unexpected changes will need to be made to the project. The Project Manager(s) shall authorize all changes or deviations in the operation of the project. Any significant changes will be noted in the project file and shall be incorporated into an amended QAPP. The Quality Assurance Officer will document the effective date of all changes made in the QAPP and distributing new revisions to all applicable personnel whenever a substantial change is made.

1.9.2 Field Data Documentation

The DEQ WQM program requires that each data generating activity be thoroughly documented. Field staff records station ID, date and time collected, survey depth, collector, laboratory group code, and the field measurements on hardcopy forms using field data sheets. At the end of each sampling day, all the field data are transcribed into the DEQ Comprehensive Environmental Data System (CEDS) database. Field data sheets will be secured in filing cabinets at Regional Offices and maintained for a seven year period.

1.9.3 Equipment Calibration and Maintenance

Procedures for operating, maintaining and calibrating instruments used for field measurements are contained in the WQM SOP manual. Personnel using field instruments are expected to read and be thoroughly familiar with all procedures detailed in the standard operating procedures. In particular, the program manager shall meticulously follow the calibration procedures given in the standard operating procedures. A calibration and maintenance logs shall be kept for each instrument. Dates of calibration and any other pertinent data shall be routinely entered in the

logbook. All maintenance activities will also be entered in the logbook. Calibration log and maintenance records shall be maintained for seven years at either the Regional Office or Central Office.

1.9.4 Laboratory Data Documentation

Documentation for analytical data is kept on file at the participating laboratories and recommended to be maintained for five years. These files should be stored such that they are always available and reviewed during external audits. These records include the analyst's comments on the condition of the sample and progress of the analysis, primary standard certification, working standard preparations, instrument calibration results, results of QC check sample/ measurements, chromatograms or instrument printouts, and final data calculations.

Laboratory analytical data that are received from DCLS or other contract laboratories have undergone extensive laboratory QA/QC procedures. The Virginia Information and Technology Agency (VITA), or designated contractor or personnel, will ensure automated upload of analytical data from the DCLS Laboratory Information Management System (LIMS) database into the DEQ central database (CEDS) daily. Contract laboratories not utilizing a LIMS database system provide analytical results to DEQ via printouts or electronic files utilizing a commonly accepted ASCII file format such as a comma delimited text file or a Microsoft Excel spreadsheet. This data is either entered into CEDS manually or by batch upload.

2.0 DATA GENERATION AND ACQUISITION

2.1 Sampling Design

2.1.1 Site locations:

Regional Offices submit their site selections annually to the Water Quality and Assessment manager for the upcoming year in mid to late December via the Yearly Run Schedule of DEQ's Comprehensive Environmental Data System (CEDS). Regions select sites based on programmatic needs – TMDL development/tracking, 305B listing/delisting, Special Studies and citizen nominations/follow up. Once all the information is received from the regional offices, the sites are downloaded by individual programs along with the parameters to be monitored to an Excel file called MonPlan. The information is then reviewed by the Water Quality and Assessment Manager and her staff to ensure site selection is appropriate for the agency's needs and fits the agency's budget constraints. If adjustments are needed, the Water Quality and Assessment Manager coordinates changes with Regional Water Quality Managers to produce the final list in January. The final monitoring plan is subsequently made available to the public on DEQ's website in Word and Excel formats:
https://www.deq.virginia.gov/home/showpublisheddocument/13594/638113652990470000.
A map is also generated of all sites and posted here:
https://geohub-vadeq.hub.arcgis.com/pages/c1ad79b7b58844f9b468f19c3907cac2.

2.1.1.1 Watershed Stations

Watershed stations are established to provide statewide, comprehensive monitoring coverage of the Commonwealth's streams by hydrologic units. In 2013, DEQ adopted the Watershed Monitoring Network to provide comprehensive coverage of all small hydrologic units in Virginia using the 6th digit hydrologic units. Due to the increased number of watersheds that will be monitored, regional offices are given the option to assign additional stations in watersheds with declining trends in water quality.

2.1.1.2 Trend Stations

Trend stations provide the data for detecting and evaluating tendencies in long-term water quality changes. Listed below are desirable characteristics for trend station site selections:

A. Free-flowing, freshwater stream:

1. Whenever possible, stations should be located in direct association with a flow gauge. Otherwise, stations should be near enough to one or more gauges to permit adequate interpolation of discharge at the site.

2. For water quality trend assessment, sites should be located near the mouths of the watershed to evaluate the loadings being discharged to subsequent (downstream) watersheds. The location of such stations may be either upstream from the outflow of one watershed, or downstream from the inflow to the subsequent watershed, but an effort should be made to minimize the number of significant tributaries that enter the gauged stream between the monitored site and the watershed boundary. On a mainstream river consisting of waters from multiple upstream watersheds, the site location should be:

    i. At or near the boundaries of USGS Cataloging Units (8-digit HUCs)
    ii. At or near the stream or river's fall line, when one exists, and
    iii. Immediately above the freshwater head-of-tide, when it exists, with the same restrictions as those described in item 1 above.

B. Tidal waters

For evaluating trends in tidal fresh and saltwater tributaries, a trend station should be located near the geographic center of the tributary, and far enough from the mouth so that a minimum of open estuary or oceanic water is sampled at flood tide. Such samples should be representative of the tributary and not the estuary or ocean. In open estuarine areas, trend stations may be located at or immediately upstream from the stream's convergence with the open estuary or ocean, or in the mainstream of a bay/embayment, in order to evaluate estuarine water quality trends.

C. All waters

Trend stations should be located outside the mixing zone of permitted discharges and sufficiently downstream from significant tributaries to permit the complete mixing of the combined water columns. Whenever possible, sites should be located where adequate biological monitoring can be accomplished.

2.1.2 Sample Number and Types

The water quality monitoring network consists of approximately 825 stations annually (about 350 watershed stations, 350 trend stations, 125 probabilistic stations) for which approximately 20,000 water column samples are collected each year. In addition to field measurements performed by DEQ monitoring staff, the DCLS performs approximately 30,000 analyses on submitted samples annually. All stations are sampled for the parameters as listed in Table 1.

Most of the stations are located at bridge crossings and can be identified using route numbers or by noting latitude and longitude. Estuaries and other large water bodies are usually monitored by boat and sample sites are confirmed using GPS latitude and longitude. The water column sampling points are generally mid-channel, or as determined by field staff to be representative of the water body. Sampling locations are sites:

1. Where flow is significant enough to ensure a relatively well-mixed, homogenous sample
2. Outside of effluent mixing zone
3. On the upstream side of the bridge whenever possible
4. Not directly below large amounts of debris or other temporary obstructions.

Field staff will determine station locations prior to sampling and perform reconnaissance on the sites to determine accessibility. If a trend station location is inaccessible during a sampling event, field staff should not sample a nearby location such as the next bridge crossing but should return at another time to sample the site. Long term inaccessibility to a sample site, such as due to bridge construction, should be assessed by the regional water quality monitoring manager for consideration of a temporary suspension or permanent discontinuation of the station. It is important that trend stations are not moved without sufficient reason to provide an uninterrupted long term record. If for some reason the trend station needs to be moved, a comparison study needs to be conducted to ensure comparability of the data.

2.1.3 Sampling Frequency

Watershed stations are sampled for core indictors monthly over a one year period. Resources permitting, sediment samples may be obtained once during a sampling year for metals and other toxics. Trend stations are sampled for core indictors bimonthly. When resources permit, sediment samples may also be obtained once every five or six years for metals. Probabilistic samples are collected once per year for water column and when resources allow, sediment samples for select parameters. Stations sampled to assess geometric mean bacteria conditions will be sampled at a frequency of at least 10 samples in a 90 day period. Due to staffing limitations, sampling for other parameters may not occur at the time of sampling for every bacteria sampling event.

In the event personnel cannot sample a run according to schedule, team leads and managers make every attempt to reschedule the run as needed to meet agency DQOs (Data Quality Objectives) required by individual programs. When runs are rescheduled, the change is then posted in the CEDS WQM module and notification is subsequently sent to the laboratory the following morning.

2.1.4 Source of Variability

Potential sources of variability include field methodology, laboratory analyses and seasonal variability. To reconcile these potential sources of variation, Central Office provides a SOP Manual to all regional personnel and requires field duplicates to be collected by each Regional Office. This provides a uniform method of sampling and tests for individual variation to ensure comparability within and across regional boundaries. Laboratory personnel are also required to analyze samples in replicate to ensure sound laboratory procedures are utilized. Finally, to address seasonal variation, samples are collected year round to ensure each season is adequately represented.

2.2. Sampling Methods

The latest WQM SOP manual in use by the agency is available at https://www.deq.virginia.gov/home/showpublisheddocument/4826/637479691614670000. Prior versions of the SOP are stored in the CEDS database under special study code 000002 and are available upon request. The SOP manual provides the following information:

- Process for cleaning and decontamination of sampling equipment
- Preventive maintenance
- Preparation of sample containers
- Quality assurance procedures
- Field sample collection procedures and methods
- Field analyses
- Sample handling and transport
- Personnel safety relating to sampling activities

The types of samples/matrices, sample containers, sample volumes, field preservation, analysis methods and maximum holding times are summarized in Table 5. Additional information is available in the laboratory catalog maintained in CEDS.

2.2.1 Corrective Action for Field Activities

Field sampling staff has the primary responsibility to document failures in the sampling or measurement systems. Deviations from WQM SOP protocols are documented in the comment section in the field data sheet. If monitoring equipment fails, WQM field staff will report the problem in the comment section of the field data sheet and will not record data values for the variables in question. Actions will be taken to replace or repair broken equipment prior to the next field use. No data will be entered into the CEDS database that is known to have been collected with a faulty instrument.

2.3 Sample Handling and Custody

Proper sample handling procedures for water and sediment samples are provided in the WQM SOP. The WQM CEDS database contains additional information regarding the requirements for sample container size and type, volumes, field preservations and maximum holding times for each analyte sampled for by DEQ. Table 5 provides a summary of this information for water and sediment samples.

Table 5: Summary of Sample Containers, Volumes, Field Preservation and Holding Time

Parameter for Analysis	Matrix	Recommended Containers	Typical Volume	Field Preservation	Maximum Holding Time
Alkalinity	Water	Polyethylene bottle	250 ml	4ºC	14 days
Ammonia-N	Water	Polyethylene bottle	250 ml	4ºC	24 hrs
BOD_5	Water	Polyethylene bottle	2000 ml	4ºC	24 hrs
Chloride	Water	Polyethylene bottle	250 ml	4ºC	28 days
Chlorophyll a	Water	Aluminum foil	N/A	Filter, 4ºC, keep dark	30 days (-20ºC)

Chlorophyll, benthic	Water	Plastic wide mouth bottle	1 gallon	4°C	48 hrs
COD	Water	Polyethylene bottle	250 ml	1 ml conc. H_2SO_4 to pH<2, 4°C	28 days
Dis. Mercury	Water	Perfluorinated plastic bottle	125 ml	4°C, no air gap	28 days
Dis. Metals (except Mercury)	Water	Plastic wide mouth bottle with special top	1000 ml	4°C, no air gap	180 days
E. Coli	Water	Sterile bottle	125 ml	4°C	24 hrs
Enterococci	Water	Sterile bottle	125 ml	4°C	30 hrs
Hardness	Water	Polyethylene bottle	250 ml	1 ml conc. HNO_3 to pH<2, 4°C	6 months
Nitrate + Nitrite-N	Water	Polyethylene bottle	250 ml	4°C	24 hrs
Orthophosphate-P	Water	Polyethylene bottle	250 ml	4°C	48 hrs
Sulfate	Water	Polyethylene bottle	250 ml	4°C	28 days
TKN	Water	Polyethylene bottle	250 ml	1 ml conc. H_2SO_4 to pH<2, 4°C	28 days
TOC	Water	Glass vial	40 ml	1 ml conc. HCL to pH<2, 4°C	28 days
Total Mercury	Water	Plastic wide mouth bottle	125 ml	4°C, no air gap	28 days
Total Metals	Water	Plastic wide mouth bottle with special top	1000 ml	4°C, no air gap	180 days
Total Phosphorus	Water	Polyethylene bottle	250 ml	1 ml conc. H_2SO_4 to pH<2, 4°C	28 days
TSS	Water	Polyethylene bottle	1000 ml	4°C	7 days
Particle Size	Sediment	Plastic wide mouth jar	125 ml	4°C, up to 6 months	28 days
Synthetic Organic Compounds	Sediment	Pre-cleaned amber glass jar with Teflon lid-liner	250 ml (2 jars)	4°C, up to 14 days	12 months[1] (-20°C)
TOC	Sediment	Pre-cleaned clear glass jar	125 ml	4°C, up to 28 days	12 months[1] (-20°C)
Trace metals	Sediment	Pre-cleaned clear glass jar with Teflon lid-liner	250 ml	4°C, up to 180 days	12 months[1] (-20°C)
Total Metals	Fish Tissue	Aluminum Foil	1-3 Fish	Initially 4°C, then frozen until analysis	12 months (-20°C)

(1) Sediment samples for metal, organic and TOC analysis may be refrigerated at 4^0C for up to 14 days maximum. Analysis must start within the 14 day period or the sample must be stored frozen at -20^0C for up to 12 months.

2.3.1 Sample Identification

Sample identification consists of station name, collection date and time, collector and sample depth. The station name is composed of a numerical code identifying the major river basin on which the tributary is located followed by a dash (e.g. 8- for the York River Basin), a three letter code for the stream from which the sample is obtained (e.g. PMK for the Pamunkey River) and a five digit numerical value identifying the station location in river miles to the nearest 100^{th} of a mile from the mouth of the stream (e.g. 013.10). Large stream systems may be further subdivided into major segment or sub-basin by substituting the dash with a letter. Field staff schedule the sampling run ahead of the time and utilize the CEDS database to print the sample bottle labels and field sheets before the sampling event. The labels contain the following information: station ID, date and time collected, survey depth (m), collector's initials, analytical group code and preservation. After a given sample has been collected and, if needed, the preservation has been added, a self-adhesive, waterproof label will be affixed to the container. If

the label cannot be affixed to the container the labels should be placed on a sample tag and then attached to the container.

2.3.2 Sample Packing

Unless specified otherwise, in the field, all samples will be packed in wet ice during shipment; to ensure they are kept at approximately 4^0C. Sample containers will be labeled clearly with printed labels or sample tags. All sample container caps and lids will be checked for tightness prior to placement in the cooler. A temperature blank consisting of a 250 mL sample bottle filled with colored water or a clearly marked bottle filled with tap water will be stored in each cooler and transported into the field, and preserved on ice along with ambient samples. The temperature blanks will be used by DCLS to ensure sample temperatures are preserved at $<6^0$C as required by SOP. Sample not preserved according to SOP will be Qualified as Improperly Preserved by DCLS.

Prior to shipping, the field staff drain excess water from the cooler and refill the ice to maintain the samples at $<6^0$C during transport. Samples are manually dropped off or shipped in the cooler via a contracted courier to DCLS or via a commercial shipping service to another contracted laboratory. For most samples, coolers are delivered to the laboratory by next day. Upon receipt of the samples, the laboratory transfers them to the refrigerator set at 4^0C for storage until analyzed. Handling, preparation, transport, and storage of samples are done in a manner to minimize bulk loss, analyte loss, contamination or biological degradation.

2.3.2 Sample Chain of Custody

Sample custody procedures are an integral part of laboratory and field operations. Since routine ambient monitoring data are not used for legal purposes, formal chain of custody (COC) procedures is not required. Samples requiring chain of custody such as those collected for enforcement purposes are transported to DCLS in secured, locked coolers or regular sample coolers sealed with tape. Chain of custody forms are filled in and printed from the field data screen in the CEDS WQM module at the end of the day, signed by the responsible field specialist and sealed in Ziplock bags. The COC form is then taped to the top of the cooler for transport to DCLS. It is assumed that samples in tape-sealed ice coolers are secure whether being transported to DCLS by field personnel, common courier, or by commercial package delivery.

Samples which may be used for legal purposes require formal chain of custody procedures. Detailed instructions for handling Chain of Custody Samples may be found in the WQM SOP manual.

DCLS is responsible for sample custody upon receipt of samples at DCLS central receiving by Sample Records Management (SRM) staff. Laboratory procedures for sample processing are described in detail in DCLS SOPs. Once samples are received by the laboratory, the SRM staff members check the sample bottle labels against the corresponding information in the LIMS. SRM notes any damaged or missing sample containers and checks the pH of the sample for acid preservation when chemical preservation is required. A bottle blank, included in each cooler of

samples, is checked by lab personnel for temperature at the time of sample receipt to ensure the samples are preserved at <6 °C. Any discrepancies in sample identifications, sample analysis information, missing samples, or any indication that samples are not properly preserved to the correct pH or temperature is communicated to the DEQ WQM Laboratory Liaison.

2.4 Analytical Methods

The analytical methods used by DCLS and contract laboratories for this program are in accordance with currently approved procedures given in Standard Methods for Examination of Water and Wastewater, Methods for Chemical Analysis of Water and Wastes or with other procedures approved or accepted by the USEPA. Analytical methods and approximate data turnaround times are described in Table 6. A description of the analytical equipment and instrumentation required for each analysis is included in the individual laboratory technical procedure manuals for the methods.

When problems occur during the analytical process, a corrective action is implemented. The corrective action should identify the source of the problem and eliminate it. It is encouraged for action to occur at the lowest level to resolve problem. Staff communicates corrective actions to management and documented for quality assessment to determine if additional corrective actions are necessary. A copy of a corrective action form used by DEQ is provided in Appendix A.

The laboratory supervisor of each lab has the primary responsibility for responding to failure of analytical systems to the DEQ Laboratory Liaison. Solutions which are consistent with the measurement objectives will be reached in consultation with WQM QA Coordinator.

Failures in field and laboratory measurement systems involve, but are not limited to, such things as instrument malfunctions, failures in calibration, sample jar breakage, blank contamination, and quality control samples outside of defined limits (listed in Tables 7-11). In many cases, field staff or lab analysts are able to correct the problem. If the problem is resolvable by field staff or lab analysts, then they document the problem in their field data sheet or laboratory record and complete the analysis. If the problem is not resolvable, then it must be conveyed to the respective supervisor, who makes the determination if the problem compromised the sample analysis and should therefore results not be reported. The nature and disposition of the unresolved problem needs to be documented in the data report that is sent to the WQM QA Coordinator.

Unused raw sample volume, sample extracts and sample digests are disposed of properly in accordance with each laboratory's waste management procedures. Disposal of unused raw sample for routine analysis will occur when the analysis is complete and verified to be accurate or when holding times are exceeded, whichever is less. Formal Chain of Custody samples are maintained until disposal is approved by DEQ or until holding times are exceeded, whichever is less.

Table 6: Analytical Methods and Approximate Data Turnaround Time for WQM Program

Parameters	Matrix	Analytical Method	Approx. Data Turnaround Time
Alkalinity	Water	SM 2320B/4500H+B	21 days

Ammonia-N	Water	EPA 350.1, ASTM D6919-09, USGS I-2523-85	21 days
BOD	Water	SM 5210B	21 days
Chloride	Water	EPA 300.0	21 days
Chlorophyll a	Water	EPA 446.0	21 days
Chlorophyll, benthic	Water	Stream Periphyton Monitoring Manual[1]	90 days
COD	Water	SM 5210B	21 days
Dis. Mercury	Water	EPA 245.7	90 days
Dis. Metals (except Mercury)	Water	EPA 1638	90 days
E. Coli	Water	SM 9223B	7 days
Enterococcus	Water	EPA 1600	7 days
Fecal Coliform	Water	SM 9222D	7 days
Fixed Solids	Water	USGS I-3752-85	21 days
Hardness	Water	EPA 200.7, SM 2340-C	21 days
Nitrate	Water	EPA 300, 353.2, ASTM D3867-04A	21 days
Nitrate+Nitrite-N	Water	EPA 353.2, ASTM D3867-04A	21 days
Nitrite	Water	EPA 300, 353.2, USGS I-4540-85	21 days
Orthophosphate –P	water	EPA 300, 365.1	21 days
Semi-VOC Base Neutral	Water	EPA SW846 8270	28 days
Sulfate	Water	EPA 300.0	21 days
TKN	Water	EPA 351.2	21 days
TOC	Water	SM 5310B, 5310C	21 days
Total Metals	Water	EPA 200.7, 200.8, 1638	90 days
Total Nitrogen	Water	SM 4500-N-C	21 days
Total Phosphorus	Water	EPA 365.4	21 days
TDS	Water	SM 2540.C, USGS I-1752-85	21 days
TS	Water	SM 2540B	21 days
TSS	Water	USGS I-3765-85	21 days
Turbidity	Water	SM 2130B	21 days
TVS	Water	EPA 160.4	21 days
TVSS	Water	USGS i-3767-85	21 days
VOC	Water	EPA 524.2	28 days
Mercury	Sediment	SW846 3051A (digestion),User Defined EPA 245.1	21 days
Organochlorine pesticides	Sediment	EPA 8270	28 days
Organophosphorus pesticides	Sediment	EPA 8270	28 days
PAHs	Sediment	EPA 8270	28 days
Particle size	Sediment	Applied Marine Research Lab	21 days
TOC	Sediment	NCEA-1282, EMAC-001, 9060A	21 days
Total Metals (except Mercury)	Sediment	EPA 3051A/6020B	28 days
Aluminum	Fish Tissue	SW-846 3052/EPA 6020B	60 days
Antimony	Fish Tissue	SW-846 3052/EPA 6020B	60 days
Arsenic	Fish Tissue	SW-846 3052/EPA 6020B	60 days
Cadmium	Fish Tissue	SW-846 3052/EPA 6020B	60 days
Chromium	Fish Tissue	SW-846 3052/EPA 6020B	60 days
Copper	Fish Tissue	SW-846 3052/EPA 6020B	60 days
Lead	Fish Tissue	SW-846 3052/EPA 6020B	60 days
Manganese	Fish Tissue	SW-846 3052/EPA 6020B	60 days
Mercury	Fish Tissue	SW-846 3052/EPA 6020B/7471B	60 days
Nickel	Fish Tissue	SW-846 3052/EPA 6020B	60 days
Selenium	Fish Tissue	SW-846 3052/EPA 6020B	60 days
Silver	Fish Tissue	SW-846 3052/EPA 6020B	60 days

Thallium	Fish Tissue	SW-846 3052/EPA 6020B	60 days
Zinc	Fish Tissue	SW-846 3052/EPA 6020B	60 days
Vanadium	Fish Tissue	SW-846 3052/EPA 6020B	60 days
Beryllium	Fish Tissue	SW-846 3052/EPA 6020B	60 days
Barium	Fish Tissue	SW-846 3052/EPA 6020B	60 days

[1]Biggs B, Kilroy C. 2000. Stream Periphyton Monitoring Manual. New Zealand Ministry for the Environment.

2.5 Quality Control Requirements

Data Quality Objectives (DQOs) are quantitative and qualitative statements specifying the quality of the environmental data required to support the decision-making process. The intended use of the data, analytical measurements and the availability of resources are an integral part in the development of the DQOs. DQOs define the total uncertainty in the data that is acceptable for each specific activity during sample events. The uncertainty includes both sampling error and analytical instrument error. Ideally, the prospect of zero uncertainty is the objective; however, the variables associated with the collection process (field and laboratory) inherently contribute to the uncertainty of the data. The overall quality assurance objective is to keep the total uncertainty within an acceptable range that will not hinder the intended use of the data. In order to achieve this objective, it is necessary to specify data quality requirements such as detection limits, criteria for accuracy and bias, sample representativeness, data comparability and data completeness. The overall objectives and requirements for this program have been established to assure a high degree of confidence in the data obtained. Tables 7-11 contain the data acceptability criteria used in this program.

2.5.1 Field Sampling Quality Control

QA/QC samples will be collected in the field to allow evaluation of data quality. Field QA/QC samples include equipment blanks, field split samples and preservative reagent blanks.

2.5.1.1 Equipment Blanks

To ensure the effective cleaning of sampling devices, fill the device with clean sand or deionized water or pump deionized water through the device and transfer the sand or deionized water to the appropriate sample container. Preserve the sample as would be done for a regular sample and return it to the laboratory for analysis. The equipment blank should be processed at the beginning of the sampling day. Unless otherwise specified by individual programmatic SOP (i.e. the Chesapeake Bay Program), the collection of equipment blanks may be performed in the Regional Office prior to going to field. If the sample is collected straight from the source and not by a sampling device, then an equipment blank is not necessary. Equipment blanks will be collected for all required parameters at a rate of 4% of the number of total station visit samples within annual run schedule or more frequently if specified for a special study. If the analytes of interest are detected at levels greater than three times of MDL, the field staff should be notified so that the source of contamination can be identified (if possible) and corrective measures taken prior to the next sampling event. If the concentration in associated samples is less than five times the value in the equipment blank,

the results for the environmental samples may be affected by contamination and should be qualified.

2.5.1.2 Field Split Samples

Split samples should be collected for all the parameters at a rate of 4% of the total number of stations within annual run schedule or more frequently if specified for a special study. The split sample will be collected in the same manner as the regular sample and from the same sampling device. Field split samples are collected to determine the homogeneity of the sampling device and consistency of sample handling, within the limits and constraints of the situation. For non-bacteria samples, field split results will be assessed using the relative percent difference (RPD) between replicate measurements. RPD limits for laboratories are stated in the Table 2-4. The RPD will be calculated as follows:

$$RPD= (200) (X_1 –X_2) /(X_1 + X_2)$$

Where X_1 and X_2 are duplicate sample concentrations.

For bacteria samples, RPD is not as useful of a quality assurance check due to the natural variability of bacteria in the environment and the tendency for bacteria to cling to solids. In addition, most bacteria samples processed for the agency use a subsample volume diluted into sterile water further increasing sample result variability. As a screening check of field sampling performance, split sample results are transformed to a logarithmic value and a difference of the highest and lowest split value is obtained. For samples that are greater or less than the reported detection limit, the detection limit value is used. If the difference is less than 0.60, the duplicate results are considered similar. A separate check is performed by the processing laboratory using laboratory based duplicates. Duplicate results are similarly transformed to their logarithmic value and if results are 3.27 of the average duplicate reference value used by the laboratory as outlined in Standard Methods 9020, the duplicate results are considered similar. Associated sample runs are flagged with either duplicate control value are exceeded.

2.5.1.3 Preservative Reagent Blanks

Blank samples are routinely submitted to contracted laboratories which contain the same volume of preservatives used in routine samples to confirm they are contaminant free.

2.5.2 Laboratory Analysis Quality Control

2.5.2.1 Laboratory Method Blank

The purpose of analyzing method blanks is to ensure sample contamination has not resulted from laboratory solvents, reagents or glassware used in processing the samples during the analytical process. Method blanks are prepared and analyzed by the laboratory at a rate of at

least one per analytical batch. The method blank is processed through the entire analytical procedure in a manner identical to the samples. Method blank criteria are provided in Tables 7-11. If the blank indicates contamination has occurred and eliminating the contamination is not possible, all impacted analytes in the analytical batch shall be flagged or the associated samples should be reanalyzed. In addition, a detailed description of the contamination source and the steps taken to eliminate/minimize the contaminants shall be documented. Subtracting method blank results from sample results is not acceptable.

2.5.2.2 Matrix Spike and Matrix Spike Duplicate

A laboratory matrix spike (MS) and a matrix spike duplicate (MSD) is used to evaluate the effect of the sample matrix on the recovery of the compound(s) of interest and to provide an estimate of analytical precision. Specifications for MS and MSD'S for water chemistry and sediment samples are provided in Tables 7-10. For bacteria samples, a MS and MSD check is not applicable.

A field sample is first homogenized and then split into three subsamples. Two of the subsamples are fortified with the matrix spike solution and the third subsample is analyzed to provide a background concentration for each analyte of interest. The final spiked concentration of each analyte tested in the sample is at least five times the MDL for that analyte. Additionally, the total number of spikes performed should cover the range of expected concentrations. Recovery is the accuracy of an analytical test against a known analyte addition to a sample. Recovery is calculated as follows:

$$\%R = (100)\,(X_S - X) / T$$

Where X_S is the measured value of the spiked sample, X is the measured value of the unspiked sample, and T is the true value of the spike solution added.

Recovery data for the fortified compounds ultimately provides a basis for determining the prevalence of matrix effects in the samples. If the percent recovery for any analyte in the MS or MSD is less than the recommended limit, the chromatograms (in the case of trace organic analyses) and raw data will be reviewed. If an explanation for a low percent recovery value is not discovered, the instrument response may be checked using a calibration standard. Low matrix spike recoveries may be a result of matrix interference and further instrument response checks may not be warranted, especially if the low recovery occurs in both the MS and MSD, and the other QC sample in the batch indicate that the analysis was "in control". An explanation for low percent recovery values for MS/MSD results, corrective actions taken and verification of acceptable instrument response will be included in the data package. Analysis of MS/MSD is also useful for assessing laboratory precision. The RPD between MS and MSD results should be less than the precision goal listed in Tables 2-4 for each analyte of interest.

2.5.2.3 Laboratory Control Spikes

Laboratory Control Samples (LCSs) consist of laboratory fortified method blanks. The purpose of analyzing Laboratory Control Samples (LCSs) is to demonstrate the accuracy of the analytical method. LCSs are analyzed at rate of one per sample batch. The accuracy criteria are listed in Tables 7-11. For bacteria samples, laboratory positive and negative controls are used in place of LCS. If the recovery is outside the specified range, the analytical process is not being performed adequately for that analyte and the sample batch must be re-processed and the LCS reanalyzed. If a reanalysis is not possible, the associated sample results should be qualified as biased low or high.

Table 7: Acceptability Criteria for Conventional Constituents in Water

Sample type	Frequency of Analysis	Acceptance Criteria	Recommended Corrective Action
External Calibration (3-5 standards over the expected range of sample)	Follow manufacturer or lab procedures in specific analytical protocols.	Correlation Coefficient ≥ 0.995	Determine cause and take appropriate corrective action. Recalibrate and reanalyze all suspect samples or flag all suspect data
Calibration Check Standard (Minimum of one mid-range standard prepared independently from initial calibration standard)	After initial calibration or recalibration. Every 20 samples	90-100% Recovery	
Reference Materials	One per analytical batch	Measured value <95% confidence intervals if certified. Otherwise, 80-120% Recovery	
Laboratory Blanks (method, processing, bottle, reagent)	One method blank per analytical batch	Not to exceed 3x MDL	Determine cause of problem, remove sources of contamination, and reanalyze all suspect samples or flag all suspect data
Matrix Spike	One per 20 samples or one per batch, whichever is more frequent	80-120% Recovery or within 3x standard deviation of laboratory's actual method recoveries.	Determine cause and take appropriate corrective action. Recalibrate and reanalyze all suspect samples or flag all suspect data. 0% recovery requires rejection of all suspect data.
Matrix Spike Duplicate	One per 20 samples or one per batch, whichever is more frequent	RPD < 20%	Determine cause and take appropriate corrective action. Recalibrate and reanalyze all suspect samples or flag all suspect data
Laboratory Control Sample	One per analytical batch	80-120% Recovery	
Laboratory Duplicate	One per 20 samples or one per batch, whichever is more frequent	RPD < 20%	
Field Equipment Blanks (EB)	4% of the total stations per analytical procedure per year.	Not to exceed 3x MDL	Determine cause of problem (e.g. improper cleaning, exposure to airborne contaminants), remove sources of contamination, and reanalyze all suspect samples or flag all suspect data
Field Split Samples	4% of total samples per analytical procedure per year	RPD < 30%	Determine cause and take appropriate corrective action. Reanalyze all suspect samples or flag all suspect data

Table 8: Acceptability Criteria for Trace Metals in Water including Mercury

Sample type	Frequency of Analysis	Acceptance Criteria	Recommended Corrective Action
External Calibration. Minimum three point calibration. Each set up, major disruption, and when routine calibration checks exceed specific control limits	Follow manufacturer or lab procedures in specific analytical protocols.	Correlation Coefficient ≥ 0.995	Determine cause and take appropriate corrective action. Recalibrate and reanalyze all suspect samples or flag all suspect data
Calibration Check Standard (minimum of one mid-range standard prepared independently from initial calibration standard)	After initial calibration or recalibration. Every 10 samples	90-110% Recovery	
Reference Materials	One per analytical batch	Method validation and routine accuracy assessment 75 – 125% Recovery	If matrix spikes are in control then proceed. If not, determine cause and take appropriate corrective action. Recalibrate and reanalyze all suspect samples or flag all suspect data
Matrix Spikes (Predigestion spike, postdigestion spike)	One per 10 samples	Predigestion= 70–130% Recovery Postdigestion= 80-120% Recovery	If reference materials are in control then proceed. If not, determine cause and take appropriate corrective action. Recalibrate and reanalyze all suspect samples or flag all suspect data
Matrix Spikes Duplicate	One per 10 samples	RPD < 20%	Determine cause and take appropriate corrective action. Recalibrate and reanalyze all suspect samples or flag all suspect data.
Laboratory Duplicates	One per 20 samples or one per batch, whichever is more frequent	RPD < 20%	
Laboratory Control Sample	One per analytical batch	85-115% Recovery	
Laboratory Blanks (method, processing, bottle, reagent)	One method blank per analytical batch	Not to exceed reporting limit	Blanks found above the MDL below the RL are investigated to prevent significant contamination from occurring
Equipment Blanks (EB)	Will be collected in the field at rate of 10% of the total stations	Not to exceed reporting limit	
Field Duplicates	10% of total samples per analytical procedure per year	RPD < 30%	Determine cause and take appropriate corrective action. Recalibrate and reanalyze all suspect samples or flag all suspect data

Table 9: Acceptability Criteria for Sediment Trace Metals Including Mercury

Sample type	Frequency of Analysis	Acceptance Criteria	Recommended Corrective Action
External Calibration. Minimum three point calibration. Each set up, major disruption, and when routine calibration checks exceed specific control limits	Follow manufacturer or procedures in specific analytical protocols.	Correlation Coefficient ≥ 0.995	Determine cause and take appropriate corrective action. Recalibrate and reanalyze all suspect samples or flag all suspect data
Calibration Check Standard (Minimum of one mid-range standard prepared independently from initial calibration standard)	After initial calibration or recalibration. Every 10 samples	90-110% Recovery.	
Reference Materials	One per analytical batch	Method validation and routine accuracy assessment 75 – 125% Recovery	If matrix spikes are in control then proceed. If not, determine cause and take appropriate corrective action. Recalibrate and reanalyze all suspect samples or flag all suspect data
Matrix Spikes (Predigestion spike, postdigestion spike)	One per 10 samples	Predigestion= 70 – 130% Recovery Postdigestion= 75-125% Recovery	If reference materials are in control then proceed. If not, determine cause and take appropriate corrective action. Recalibrate and reanalyze all suspect samples or flag all suspect data
Matrix Spikes Duplicate	One per 10 samples	RPD < 35% for Mercury, all other metals RPD<25%	Determine cause and take appropriate corrective action. Recalibrate and reanalyze or flag all suspect samples or data.
Laboratory Duplicates	One per 20 samples or one per batch, whichever is more frequent	RPD < 20%	
Laboratory Control Sample	One per analytical batch	85-115% Recovery	
Laboratory Blanks(method, processing, bottle, reagent)	One method blank per analytical batch	Not exceed reporting limit	Blanks found above the MDL below the RL are investigated to prevent significant contamination from occurring
Equipment Blanks (EB)	Will be collected in the field at rate of 10% of the total stations	Not exceed reporting limit	
Field Duplicates	10% of total samples per analytical procedure per year	RPD < 30%	Determine cause and take appropriate corrective action. Recalibrate and reanalyze or flag all suspect samples or data.

Table 10: Acceptability Criteria for Sediment Organic Compounds (PCB, PAH, OC, OP)

Sample type	Frequency of Analysis	Acceptance Criteria	Recommended Corrective Action
Initial Calibration	Initial to calibrate the instrument and then whenever the CCC fails	RRF must be ≥0.05 and the percent relative standard deviation (%RSD) must be ≤30%. Four compounds from calibration group may be <40% if min RRF.0.01. Analyst may use linear and sometimes quadratic curves (min. of 6 points) as long as the Corr.>0.99(linear) and R.0.995 (quad)	Stop analysis, take corrective action (prepare new standards, perform instrument maintenance), recalibrate by re-injecting the calibration standards.
Calibration Check Standard (Min. of one mid-range standard prepared independently from initial calibration standard)	Analyzed at the beginning of an analytical sequence and is good for 12 hrs shift	For 90% of the compounds per fraction, RRF must be ≥ 0.05 and the percent difference between the calculated amount and the true value for each analyte must not exceed ±25%. For the remaining 10% the analytes, the percent difference must not exceed ±35%	Re-inject the calibration check standard once. If it still fails, recalibrate by re-injecting the calibration standards.
Performance Evaluation Samples	Minimum of one per year	Limits provide by vendor, typical 75-125%	Evaluate during data validation, No immediate corrective action possible.
Method Blank	One per preparation batch	Not to exceed RL	Reanalyze the method blank once. If analyte is still over RL, re-extract and reanalyze any samples that have values that are less than ten times the levels in the blank.
Internal standard	Each sample	Internal standard area counts must not deviate by more than a factor of two 9-50% to 100%) from either the mid-point standard of the initial calibration or the last CCC.	Re-inject the sample extract. If it still fails, qualify all compounds associated with the failing internal standard(s).
Surrogate Standards	Each sample	Recovery must be within the range of 30-150%.If there are two surrogates, at least one must be 30-150% and the other >10%. If there are three surrogates, two must be 30-150% and the other >10%.	If the recovery is 10-30%, qualify all compounds associated with that fraction. If the recovery is less than 10%, re-extract the sample for that fraction.
Matrix Spike	Once per batch or once per matrix type	Recovery should be in the range of 40-140% for at least 80% of the analytes.	Re-extract and reanalyze another MS/MSD. If homogeneity is an issue choose another sample.
Matrix Spike Duplicates	Once per batch or once per matrix type	Recovery should be in the range of 40-140% for at least 80% of the analytes. Compare to matrix spike results RPD should be ≤ 30% for 80% of the analytes.	Re-extract and reanalyze another MS/MSD. If homogeneity is an issue choose another sample.

Table 10 Continued

Sample type	Frequency of Analysis	Acceptance Criteria	Recommended Corrective Action
Laboratory Control Sample – sand spike	Once per batch	70% of the target compounds should be within ±35% of the true value.	Evaluate the lab control sample in conjunction with the MS/MSD results. If the MS/MSD results ate acceptable, re-extract another lab control sample. If the MS/MSD is unacceptable, re-extract all samples and QC associated with the batch.
Target Analyte List (TAL) Identification	All detected TAL's in samples	Mass ratio of primary ion to secondary ion must be within 20% of the expected value.	NA
Field Split Samples	One per ten samples	RPD should be <40%.	Evaluate during the data validation. No immediate corrective action possible.

Table 11: Data Acceptability Criteria for Bacteria-Pathogen in Water Sample

Sample type	Frequency of Analysis	Acceptance Criteria	Recommended Corrective Action
Field Duplicates	4% of total bacteria samples per year	≤10x difference between the highest split and lowest split from the same sample event.	Determine if problem was due to sampling procuress or from natural conditions. Take appropriate corrective action if needed. Flag all suspect data.
Lab Method Blanks (Sterility Checks)	One per batch	< reporting limit	Identify contamination source. Check reagents. Re-analyze blank
Lab Duplicate	One per batch	$R_{log} \leq 3.27 * \text{mean } R_{log}$	Recalibrate and reanalyze
Lab Negative Control Samples	One per culture medium or reagent lot	< reporting limit	Identify source. Clean equipment and prepare new media. Re-examine negative control.
Lab Positive Control Samples	One per culture medium or reagent lot	≥ reporting limit	Identify and correct problem. Re-examine positive control.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance

To minimize downtime of measurement systems, all field and laboratory instrument/equipment must be maintained in working condition. Environmental Field Specialists and laboratory technicians inspect instruments and equipment in the lab daily. Corrective action is immediately taken when problems are found. Backup instruments /equipment or common spare parts will be available so that if any piece of equipment fails during use, repairs or replacement can be made as quickly as possible and the measurement tasks resumed.

2.6.1 Field Measurement Instrument/Equipment

All field instrument/equipment having manufacturer recommended schedules of maintenance will receive preventive maintenance according to that schedule. Environmental Field Specialists in each Regional Office have the responsibility to ensure the preventive maintenance schedule listed in the WQM SOP is followed. Other equipment used only occasionally will be inspected at least monthly and especially prior to being taken into the field for availability of spare parts, cleanliness, battery strength, etc. Common spare parts which should be available in the lab include, but are not limited to batteries, tubes, rubber tubing, o-rings, membranes, electrolyte, and replacement probes. If performance checks or calibration procedures indicate that a problem exists, appropriate maintenance must be conducted immediately or the equipment is returned to the manufacturer for service. Defective equipment will not be used operationally until repaired and satisfactory performance results are achieved.

A preventive maintenance logbook is maintained in the Regional Offices documenting maintenance performed on each instrument. The regional program coordinator periodically reviews the logbook to identify equipment with high repair records and to determine which specific items require the most frequent repairs or replacement. Depending on the difficulty of replacement, these items should be added to the list of critical spare parts to be maintained at the Regional Office.

SOPs for preventive maintenance of field equipment and the required documentation are contained in the WQM SOP.

2.6.2 Laboratory Analysis Instrument/Equipment

The primary goal of the laboratory's preventative maintenance programs is to prevent instrument and equipment failure and to minimize instrument down time when failure occurs. The laboratories maintain an inventory of replacement parts needed for preventative maintenance and spare parts that routinely need replacement (e.g. septa, gauges, source, detectors etc.). Implementation and documentation of the preventative maintenance program according to the laboratory preventative maintenance policies in the QA Plan is primarily be the responsibility of analysts using the instrumentation.

2.7 Instrument/Equipment Calibration and Frequency

Field and laboratory equipment and instruments require routine calibration checks to verify that their performance is within acceptable quality standards. The following sections will discuss procedures and frequency for instrument calibrations.

2.7.1 Field Measurement Instruments/Equipment:

The field multiprobe instrument must pass QA checks according to the weekly calibration schedule (Table 12) or be calibrated prior to each sampling event. Sensors for all planned multiprobe sampling parameters are calibrated at the beginning of the week according to

manufacturers' guidelines. Dissolved oxygen is calibrated daily. Mid-week calibrations for pH and specific conductance are dependent upon the previous day's end of day check. Regional offices maintain a calibration logbook for each multiprobe. Each book contains a set of instructions on how the calibration should be performed and a chart for documentation of calibration date, time, pH standards used, saturated dissolved oxygen, temperature, barometric pressure reading, conductivity calibration reading, initials of personnel, and comments. The chart documents morning calibration results and calibration checks performed at the end of each sampling day. A brief summary of the requirements for calibration by parameter is given below:

Barometer: The internal barometer used in many multiprobe units is an essential component to properly calibrate dissolved oxygen sensors. Probe based barometers are routinely checked against a laboratory benchtop barometer of known accuracy or the nearest National Weather Service maintained weather station barometer that is adjusted to the altitude of the location where the multiprobe is calibrated. If the multiprobe barometer is outside of 5 mmHg of the reference barometer, the probe barometer is adjusted or sent to the manufacturer for service.

Conductivity Sensor: The conductivity sensor must be calibrated at the beginning of the sampling week according to manufacturer's specifications prior to use in the field against a reference solution that approximates the ambient conditions that will be measured that day. The sensor is also checked at the end of the sampling day against the same reference standard strength used for calibration. Mid-week calibrations are conducted when a previous day's end of day check was outside of the calibration tolerance limits (±2% of reference solution). Sensors not used on a previous day require calibration before use in the field.

Depth Sensor (pressure transducer): Depth sensors on multiprobes are calibrated at the sample site prior to deployment at a set depth specified by the manufacturer. This in effect becomes the standard for depth calibration.

Dissolved Oxygen Optical Sensor: Calibration of the optical dissolved oxygen sensor is performed in a water saturated air environment at the beginning of the sampling day. At the end of the sample day, the optical DO sensor is checked for drift by comparing readings to the theoretical saturation point based on barometric pressure and temperature. If the sensor has drifted greater than 0.1 mg/L and less than 0.20 mg/l of theoretical values the probe is serviced before deploying on the next sample run. If the end of day check produces a drift of greater than or equal to 0.20 mg/L and verification of the reading shows the error, affected field dissolved oxygen readings are not keyed into CEDS. Large drifts usually indicate improper calibration or damage to the luminescent membrane requiring maintenance. Winkler titration or comparison with other calibrated sensors is the primary method to validate the accuracy of the dissolved oxygen sensor to diagnose sensor performance.

pH Sensor: The pH sensor must be calibrated at the beginning of the sampling week using a minimum of two standard buffer solutions that bracket the expected pH of the samples to be measured (e.g. 4.0 & 7.0 or 7.0 & 10.0). Field teams are encouraged to periodically validate the slope of the pH calibration using a third buffer standard (4 or 10) prior to going into the field. The calibration of the sensor must be checked at the end of the day against the same standards

used for calibration in the morning. If measurements in the field were outside the bracketed standards used for calibration, the unit is verified with a third buffer (4 or 10) that brackets the observed readings to ensure sensor accuracy. If the sensor has drifted more than ±0.20 pH units from the buffer value at the end of day, the validity of the readings should be verified. If verification fails, affected field pH measurements are not keyed into CEDS. A diluted pH solution of known value or comparison with other calibrated sensors is the primary method to validate the accuracy of the pH sensor to diagnose sensor performance. Mid-week calibrations are conducted when a previous day's end of day check was outside of the calibration tolerance limits (±0.1 SU of reference solution). Sensors not used on a previous day require calibration before use in the field.

Temperature Sensor: The temperature sensor is verified once a year against a NIST certified thermometer using water baths covering a range of temperatures encountered in the field. The instrument and thermometer should agree within 0.5°C. At least six months from the time of the annual verification, regions will compare temperature accuracy by comparing two field units using three water baths which mimic the full range of routinely encountered temperatures. If the units display readings outside 1.0°C, the units are validated with the NIST certified thermometer before taken back out to the field.

Turbidity and other sensors: Other sensors occasionally used by field teams such as turbidity and chlorophyll are calibrated prior to deployment according to manufacturer instructions and calibration standards. Typically said calibrations involve a zero check or calibration followed by a slope calibration of a known standard.

Table 12. Multiprobe calibration schedule summary.

<table>
<tr><th rowspan="2">Parameter</th><th rowspan="2">Beginning of Week</th><th colspan="3">During the Week</th></tr>
<tr><th>Do Not Recalibrate</th><th>Factory Reset Recalibration</th><th>Service Required</th></tr>
<tr><td>pH</td><td rowspan="2">Calibrate prior to sample run at start of week</td><td rowspan="2">Previous day end of day check within calibration tolerance</td><td rowspan="2">Previous day end of day check within end of day check tolerance</td><td rowspan="4">Previous day end of day check outside end of day check tolerance</td></tr>
<tr><td>Specific Conductance</td></tr>
<tr><td>Barometric pressure</td><td colspan="3">Check daily prior to DO calibration</td></tr>
<tr><td>Dissolved oxygen</td><td colspan="3">Calibrate daily</td></tr>
<tr><td>Depth</td><td colspan="4">Calibrate at each site</td></tr>
</table>

2.7.2 Laboratory Analysis Instruments/Equipment:

Calibration of laboratory analytical instrumentation is required to assure the data generated meet data quality objectives. Detailed calibration procedures, calibration frequencies and acceptance

criteria are specified in the analytical method SOP. Each laboratory is responsible for the proper calibration and maintenance of laboratory analytical equipment. Calibration activity performance is documented and is available for review during internal and external laboratory audits.

In general, reference standards are used to "bracket" the expected concentration of the samples. At a minimum, this generally requires the use of three to five different standard concentration levels to quantify the instrument's linear range. Calibration of instruments must be performed prior to the analysis of samples and then at periodic intervals (continuing calibration) during the sample analyses to verify that the instrument is still calibrated. Sample concentrations outside the instruments linear range need to be diluted and if necessary, reanalyzed.

2.8 Inspection/Acceptance Requirements for Supplies and Consumables

This program only utilizes supplies and consumables that are of adequate quality to sustain confidence that the data generated by the sample collection, processing and laboratory analyses will meet the associated data quality objectives. Where no independent assurance of quality for outside supplies is available, procedures are established to ensure that the quality of the purchased materials is consistent with the overall program technical and quality criteria. Purchased supplies and consumables are not used until they have been inspected, calibrated or otherwise verified to ensure compliance with any relevant standard specifications for use in this program.

2.8.1 Field Sampling Supplies and Consumables

A designated DEQ Environmental Field Specialist Senior inspects chemicals, regents, bottles, and cubitainers upon arrival. Any broken bottles and containers are shipped back to the manufacturer for replacement.

Laboratory technical staff will be responsible for inspecting incoming equipment and supplies before placing them in service. The manufacturer's specifications for product performance and purity will be used as criteria for acceptance or rejection of supplies and consumables.

2.8.2 Documentation and Tracking of Supplies Consumables

Regional offices are responsible for purchasing all the necessary consumables required for sampling either through direct purchase or by providing a list to Central Office if requested. Information for the required consumables is stored in CEDS in the laboratory catalogs module for each analysis group required by programs as listed in the MonPlan. In instances where pre-cleaned equipment or bottles are required such as Bacteria Bottles or sterilized hoses and containers required for clean metals sampling, regions request DCLS provide the containers or sterile sample containers are purchased from Environmental/Laboratory supply companies such as Fisher Scientific. DEQ makes all purchases following procedures for acquiring goods from mandatory sources (designated state agencies), state contracts and Minority Owned and Small or Micro Businesses (SwAm).

Records for purchases and receipt of supplies and consumables utilized in the field and laboratory will be maintained at the Regional Offices and contracted laboratory. Return of damaged or inappropriate materials to the suppliers will also be documented.

Documented procedures shall exist at each laboratory for the purchase, receipt, handling/storage and tracking of supplies and consumables to be used for the technical operations. The established procedures must enable program personnel to ensure that supplies and consumables that have not been tested, have expired, or do not meet acceptance criteria are not used for the program.

Each laboratory shall retain records for all the standards, reagents and media including the manufacturer/vendor, the manufacturer's certificate of analysis or purity, the date of receipt, recommended storage conditions and expiration date after which the material shall not be used unless it reliability is verified by the laboratory. The original containers shall be labeled with a unique identifier that links the containers to the aforementioned records and includes the date the container was opened.

2.9 Data Acquisition Requirements

Data will primarily be generated through WQM field activities and consequent laboratory analyses. If data from sources other than DEQ will be utilized for DEQ purposes, the outside source and their contracting laboratories must have a Quality Assurance Project Plan reviewed and approved by the DEQ Quality Assurance Coordinator for that use. Laboratory analysis performed by outside data sources must be certified complaint under the Virginia Environmental Laboratory Accreditation Program (VELAP) or applicable authority.

2.10 Data Management

2.10.1 Data Recording

Field observations and records such as sample collection information will primarily be recorded manually using a field data sheet. All field data sheets will be filed at the Regional Office generating the data. Validated field data will be entered into the CEDS database at the end of sampling day. The CEDS database has a range check system built into the data entry screen. Values exceeding the programmed maximum for a given field parameter are automatically removed from the screen and an error message is generated to inform the field specialist that an invalid value had been entered.

2.10.2 Data Validation

The data validation process is described in section 4.2 of this QAPP.

2.10.3 Data Transformation

Data transformation is expected to consist of transferring test results from one unit of measure to another (i.e. mg/kg to µg/kg). Transformation will be automated within the database to prevent

transcription errors and the number of significant figures reported will be sufficient to prevent rounded or truncated results.

2.10.4 Data Transmittal

The laboratory's electronic data files are loaded into the CEDS database via an automated File Transfer Protocol (FTP). Once the files have been processed by the system, they are archived on the server to retain the original data files.

2.10.5 Data Reduction

Data reduction is addressed in Section 4.1.

2.10.6 Data Analysis

WQM staff at Central Office will perform data analysis of field and laboratory data. Data checks for transcription errors during data entry for exceedances of maximum and minimum thresholds established by analyzing historical data are conducted while data entry is performed. Analytical data are reviewed by three chemists and require signature by Chemical Seniors prior to release. These data are then analyzed when uploaded by for completeness during the automated upload process and both OIS and CO WQM personnel are notified by email whenever there is an upload failure or error. Programmatic data are identified in DEQ's Oracle database by a two letter programmatic code and, if needed by a special study code to identify individual projects (e.g. CB for Chesapeake Bay Monitoring Data and 20000 for Ambient water quality monitoring studies). While all data are available for use across programs, data are identified so that they may be readily identified and downloaded for their intended use. Refer to Appendix C for the parameters collected by DEQ by program and applicable criteria. The program identifiers are listed below and are available to the public in the MonPlan on posted annually on DEQ's website:

AL	Algae Project
AW	Ambient Watershed Monitoring
BN	Chesapeake Bay Non Tidal Network Monitoring
C2	Coastal Probabilistic Program
CB	Chesapeake Bay Water Quality and Habitat Monitoring
CM	Citizen Monitoring requests performed by DEQ
DR	Dan River Fly Ash Spill
FI	Facility Inspections
FP	Freshwater Probabilistic
FT	Fish Tissue and Sediment Program
GW	Groundwater Characterization Monitoring
HB	Harmful Algal Blooms
IM	Post TMDL Implementation Monitoring
IR	Incident Response
PA	Probabilistic Ambient Monthly Physical and Chemical Monitoring
PC	Pollution Complaint Investigation/Spill containment (PREP)
PE	Potomac Embayment Network

PT	Freshwater Probabilistic FP Stressed
QA	Quality Assurance
RB	Benthic Biological Monitoring
RL	Reservoir Monitoring
SS	Special Studies
TM	TMDL Program
TR	Ambient Trend Program

Most of DEQ's data are used to answer questions for EPA requirements or management (State water control board, DEQ management, the Secretary of Natural Resources etc.) reporting - 305B/303D assessments, EPA's bmp database, and TMDL modeling and subsequent reporting to the DEQ management, the Secretary of Natural Resources, the General Assembly, the State Water Control Board and the public. During the reporting processes data are analyzed using descriptive statistics (min, max, averages etc.) and also compared to historical data to identify outliers prior to using regression analysis such is as Seasonal Kendall analyses, Weighted Regressions on time, discharge and Season (WRTDS, USGS) to determine status and trends or compared to criteria (refer to Appendix C) for assessment on water quality. Data may also be provided to sister agencies of the Commonwealth to assist in their tasks of protection of human health (Department of Game and inland Fisheries and Department of Health).

In the case of assessments, data are compared to criteria (Appendix C) and a 10.5% exceedance threshold is set for determining full support or impairment for conventional parameters (i.e., dissolved oxygen, pH, and temperature). A segment of water is considered impaired when a segment has at least 2 exceedances at a rate that is greater than 10.5%. Guidelines for assessments may be found at https://www.deq.virginia.gov/our-programs/water/water-quality/assessments/wqa-guidance-manual.

TMDL data and TMDL models are designed to determine where BMPs should be implemented and to follow up on water quality after implementation to determine if the BMPs produce the desired results. Likewise Status and Trends analyses are used to monitor long term changes in water quality as a result of anthropogenic and naturogenic processes or provide baseline data to provide a comparison in the event of changes over time and aid with site selection for future monitoring. Results are also used to aid in long term planning for predicted changes due to climate change, development or erosion.

2.10.7 Data Tracking

The flow of data through the system includes loading, verification, and validation.
The current system of data tracking is as follows:

Analytical files produced by DCLS are placed on their FTP site. The files are obtained daily by DEQ and loaded into the CEDS database via an automated program. An automated notification process informs specified personnel at DCLS when the files are downloaded by DEQ. If no notice is generated, DCLS personnel notify DEQ technical personnel that the download program

did not perform properly. If, during the upload to the CEDS database an error occurs, an automated error message is generated and e-mailed to DEQ technical personnel who then track down the source of the error.

DEQ also generates files for DCLS twice daily containing the field data and sample containers collected on the previous sampling day and the analytical services required for each sample container. An additional file is generated from the monthly run data module of CEDS to give the analytical chemists an idea of services that will be requested such that they can be sure to have the available reagents and bacterial media available on a given day.

Each data record in the CEDS database is date/time stamped when it is downloaded to a file generated for DCLS. DEQ personnel check the automated report daily to ensure all samples collected in the field on the previous day have been processed by the system. Additionally, sample analysis requests as scheduled in CEDS are output to a report by the DCLS LIMS database and manually checked in central receiving against each container received by the lab. DCLS then notifies the DEQ Laboratory Liaison or one of four designated alternates when samples are received without the accompanying electronic information or if they have received electronic information for samples not sent to the lab.

2.10.8 Data Storage and Retrieval

The information management system is a commercially available client/server based relational database system allowing connections of multiple users. An Oracle 12c database provides a central repository for all the data. Multiple users can connect to the system from their workstations over the internet via a web interface. Basic workstation requirements are:

- Pentium G640 2.8GHz or faster PC
- 4GB RAM, 1.5 GB of free hard disk space
- Windows 10 or equivalent

The data management system is highly secure with firewall protection and multiple layers of user authentication. Within the system itself, security administration allows users to be assigned to a group with various permissions controlling what each user can access. User access to data in the database, reports, table administration, and many other features are all controlled. The database manager is required to provide a list of approved users for the system and define user groups with associated security levels. In addition, backups of the database are run daily to ensure data preservation. Backups of the data will be retained in a separate secured location.

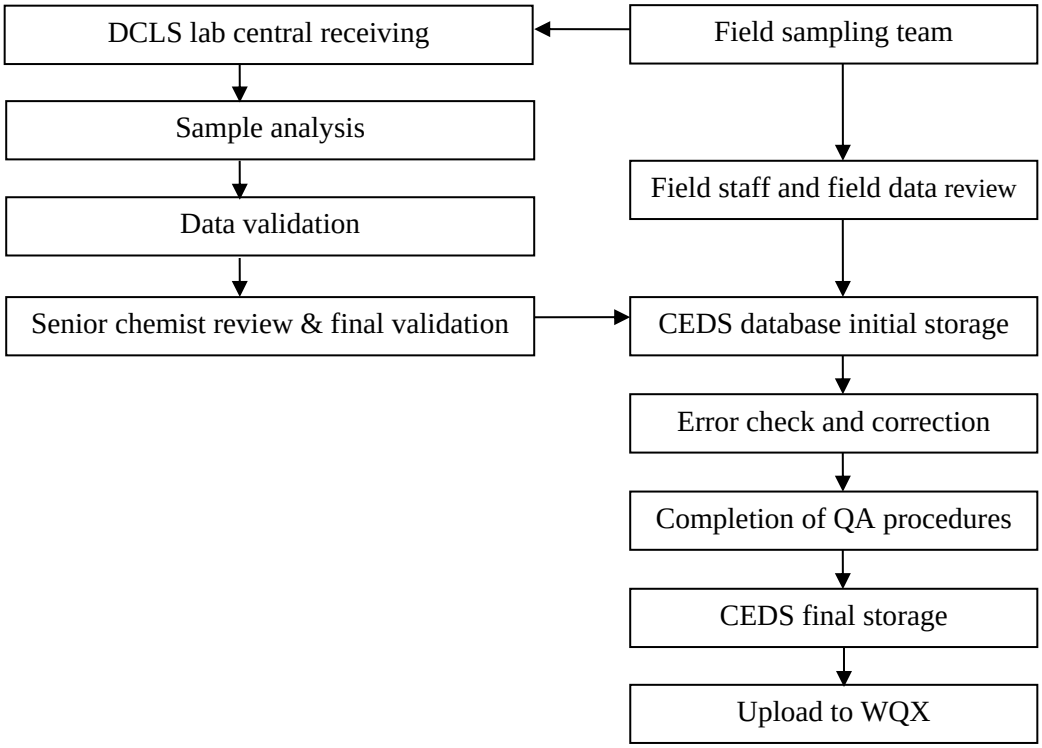
Retrieval of the data can be accomplished through the web interface. Approved users can download the data to their computers for use in a spreadsheet, run customized reports, process customized queries, or simply review the data through an explore like window.

The WQM data stored on the CEDS database is uploaded automatically to the EPA Water Quality Exchange (WQX) database though a WQX client node. This provides a copy of the data that is accessible to third parties for download. In addition, the data uploaded to WQX provides

additional offsite redundancy. Data requiring flagging or correction in CEDS is communicated to WQX during the next upload cycle.

Figure 3 illustrates the data flow from measurement in the field to final use and storage.

Figure 3: Data Flow



3.0 ASSESSMENT AND OVERSIGHT

3.1 Assessments/Oversight and Response Actions

Performance and system audits of both field and laboratory activities are routinely conducted to verify that sampling and analysis are performed in accordance with the procedures established in the SOP and QAPP.

3.1.1 Audits of Data Quality

Field blank and field duplicate data will be reviewed in order to assess the quality of sampling activities.

Analytical and measurement data should be reviewed in order to assess the quality of measurement and analytical activities, respectively.

Metadata should be reviewed in order to assess precision and accuracy.

The WMA Quality Assurance Coordinator has the ultimate responsibility to accept or reject data.

3.1.2 Technical Systems Audits

3.1.2.1 Field Sampling Audits

Field sampling audits evaluate field operations in comparison to the written procedures outlined in SOPs and other requirements established in the project plan and WQM SOP. The WQM QA Coordinator, or designated staff member, will conduct field sampling audits at each Regional Office at least once a year. Additional audits will be scheduled if warranted by the initial audit observations and findings. The primary audit elements for the program are:

- Availability, appropriateness and use of field SOPs.
- Sampling methodology
- Sample handling procedures
- QA procedures
- Field instrument operation logbook
- Field maintenance logbooks
- Field documentation
- Field data quality, quantity and timeliness
- Follow-up on previous corrective action and recommendations

The WQM QA Coordinator will prepare, or review and approve the audit report prepared by the designated staff member, which discusses deficiencies found during the on-site evaluation with recommendations for corrective action. The report will be forwarded to the regional water quality monitoring program managers.

3.1.2.2 Laboratory Performance and Systems Audits

Internal and external audits are conducted regularly at DCLS to monitor the overall effectiveness of the quality assurance system. The DCLS QA Officer of that specific lab performs internal audits. They are responsible for all QA/QC functions in the laboratory, and/or members of the professional laboratory staff that do not normally work in the section or analytical unit being audited. Non direct employees of DCLS perform external audits are in order to provide an independent and unbiased review of laboratory operation.

There are two types of audits: system audits and performance audits. 1) System audits involve an in-depth review and evaluation of some or all of the components of the analytical laboratory to determine if guidelines listed in the QA plans are properly applied. 2) Performance audits require the analysis of blind samples or other samples whose values are not known to the analytical lab. These results are used to evaluate the accuracy of the lab analytical system.

1) Internal Audits

The QA Officers conduct several system audits each calendar year. During these audits, one or more components of a lab are reviewed to determine if that part is functioning in compliance with the DCLS Quality Manual, the approved standard operating procedures and approved methodology. An audit report includes a list of deficiencies that must be addressed in order to correct or improve the lab operations.

System components to be audited during the internal audit include, but are not limited to:

- All documentation associated with sample and data handling, to include linkage mechanism employed between all records for tracking documentation for any sample data result.
- Use of established approved procedures as outlined in the Quality Manual.
- Personnel training records
- Proper execution of established procedures.
- Follow-up to corrective actions from previous audits.
- Sample and data handling activities: all sample login, routing and disposal; sample preparations; method calibrations; sample analyses; data reduction, validation and reporting; preventative maintenance and repair procedures; standard and reagent preparation, documentation and storage; sample and waste disposal; container and lab ware decontamination; QC management practices and assessment of analytical precision, accuracy and sensitivity.
- Deficiency lists and associated corrective action orders are formally communicated to responsible staff.

2) External Audits

External audits are performed when certifying agencies conduct on-site inspections. USEPA, NELAC, or other certifying authority conducts external laboratory systems and performance audits.

3.1.2.3 Performance Audits

The laboratory is involved in external performance audits conducted through the analysis of performance evaluation samples provided by the QA Officers or a third party provider. These audits consist of performance sample audits and blind sample audits.

1) Performance Sample Audits

Performance sample audits are conducted periodically by the DCLS QA Officers and DEQ using commercially prepared samples as blind samples. The results of these audits are documented and reported to managers so that any necessary adjustments can be made.

2) Blind Sample Audits

Blind sample audits are performed by submitting QC samples to the analyst. The true values are only made known after the test is completed. Blind sample audits are carried out by the DCLS QA Officers, DEQ, and certifying agencies as necessary to assure the lab is capable of achieving success with a blind QC sample.

3.1.4 Corrective Action

The first level of responsibility for identifying the need for corrective action is with field and laboratory technical staff during routine sampling and analysis activities. The second level of responsibility is with any person observing deviations during field audits, while reviewing field documentation, or while reviewing laboratory results.

Each time the need for corrective action is identified; the problem and steps taken to resolve it are documented on the corrective action request and tracking form used by DEQ (Appendix A), or similar variant. This form documents the problem, the recommended corrective action, mechanism of implementing the corrective action and responsible personnel.

3.1.4.1 Field Corrective Action

Corrective actions will be initiated if the field team is not adhering to the prescribed sampling or documented procedures or if laboratory analyses are experiencing interference or systematic contamination due to field sampling procedures or sample handling protocol. Corrective actions begin with identifying the source of the problem. Corrective action responses may include more intensive staff training, modification of field procedures, or removal of the source of systematic contamination. Once resolved, the corrective action procedure will be fully documented.

3.1.4.2 Laboratory Corrective Action

Problems should be resolved at lowest level possible. When quality assurance data exceed a threshold of acceptable limits corrective action should be taken immediately and all actions documented. Laboratory staff notifies supervisors when unsure of the appropriate corrective action. The group manager, senior chemists, principal, QA Officer, QA Manager and laboratory administration review all corrective actions. The QA committee member will compile quality assurance data and corrective actions in monthly summaries and summit it to the QA Officers on a monthly basis. The QA Officers provide recommendations and continue to monitor to ensure detected problems are resolved. If the initial corrective action fails to resolve the problem or a trend is established, the QA Officer may make additional recommendations or establish an action team to seek a resolution. The goal of the laboratory is to detect problems early, implement changes to improve services, and monitor for effect.

3.2 Reports to Management

The WQM QA Coordinator will prepare QA reports to DEQ management and regional program managers on a quarterly basis.

Each report will address the following topic areas:

- Results of performance and system and field audits.
- Evaluation of compliance with QA project plan.
- Evaluation of data quality measurement trends.
- Identification of QA problems, program needs and recommendations for solutions.

The WQM QA Coordinator will prepare an annual Quality Assurance report. The quality assurance report will summarize the results of QA/QC assessments and evaluations, including precision, accuracy, comparability, representativeness and completeness of the monitoring data; will provide a summary of the field split and equipment blank analyses and will provide a summary of any lab and/or field performance audits that were conducted. The annual report will be distributed to the program managers and management.

4.0 DATA REVIEW AND USABILITY

4.1 Data Review, Verification, and Validation Recruitments

The field, laboratory and data management activities described in this QAPP will be reviewed to assess whether these activities were performed in a manner that is appropriate for accomplishing the program objectives. This assessment will include electronic verification of the data and data validation. Data verification is confirmation by examination and provision of objective evidence that specified requirements have been fulfilled. Data verification concerns the process of examining a result of a given activity to determine conformance to the stated requirements for that activity. Data validation is confirmation by examination and provision of objective evidence that specified requirements have been fulfilled. Data validation concerns the process of examining a product or result to determine conformance to the user needs.

4.1.1 Review of Sampling Design

The ability of the collected samples to conform to sampling design specifications in section B1 of the QAPP will be reviewed by the WQM QA Coordinator. Those samples that deviate from the sample design and may impact program objectives, if any, will be discussed in the monthly water monitoring and assessment conference call.

4.1.2 Review of Sample Collection Procedures

The sample collection procedures will be reviewed to confirm that samples are collected in accordance with section B2 of this QAPP. The review will note unacceptable departures, if any from the sample collection methods outlined in the WQM SOP and identify sample data (analytical or field) that should be excluded from incorporation into the database.

To assure that all field data are collected accurately and correctly, field audits as described in section C1 will be performed during sample collection to document that appropriate procedures are being followed with respect to sample collection. These audits will include a thorough review of information related to sample collection.

The data review of equipment blanks and other field QC samples will provide definitive indications of the data quality. If the data indicate a problem exists in the sampling or analytical procedures, the problem can be quickly isolated via the complete sample tracking and documentation procedures that are performed. If such a problem does arise, corrective action can be instituted and documented. If there is compromised data due to a problem, the appropriate data qualifications will be used to identify the data.

4.1.3 Review of Sample Handling

The labeling and identification of samples will also be reviewed to ensure samples properly represent the location they were intended to represent. It is expected that labeling errors will be minimal due to use of preprinted labeling and checks in the database.

The handling, preservation and storage of samples collected during the sampling will be monitored on an on-going basis. The field audits described in section C1 will provide documentation on proper handling of samples during collection and processing. The WQM Managers will review these audits to determine if sample representativeness was maintained during collection and processing. Additionally, laboratories will document sample receipt including proper containers and preservation. Any deviations from the accepted practices will be provided to the DEQ Laboratory Liaison who will notify the appropriate regional personnel for action. Data identified as having sample handling, storage or preservation problems will be qualified to warn the data users of possible data quality deficiencies.

4.1.4 Review of Analytical Procedures

The use of proper analytical procedures described in section B4 of this QAPP will be reviewed primarily through the data verification and validation methods discussed in section D2. Qualification of data that does not conform to criteria is also discussed in section D2.

The DEQ Laboratory Liaison will review the analytical requests scheduled in the database and parameter completeness reports to confirm that samples were tested using the correct analysis methods. The review will determine if samples submitted for analysis actually had the analyses performed. If the analyses that were identified to be performed were not actually performed (due to loss of sample, lab error etc.) then a determination should have been made at the time the missing data was discovered and appropriate corrective action documented.

4.1.5 Review of Quality Control

The review of quality control checks described in section B5 of this QAPP will be conducted primarily through the data verification and validation methods discussed in section D2. Qualification of data that does not conform to criteria is also discussed in section D2.

4.1.6 Review of Calibration

The review of quality control checks described in section B7 of this QAPP will be conducted primarily through data verification and validation methods discussed in section D2. Qualification of data that does not conform to criteria is also discussed in section D2.

The regional water quality monitoring managers will review field equipment calibrations and identify any impacts to non-analytical data that may exist.

4.1.7 Data Reduction and Processing

Data generated through field activities and laboratory operations shall be reduced and validated.

4.1.7.1 Field Data Reduction

Field data will be recorded manually on a field data sheet at the time of measurement. These data include date and time collected, station ID, weather, tide or flow, field probe measurements such as temperature, dissolved oxygen, pH, conductivity, and the collector's initials. If errors are made on the field data sheet, results will be legibly crossed out, initialed by the person making the correction, and corrected in a space adjacent to the original entry. The field data will then be entered into CEDS database at the end of sampling day. To minimize transcription errors and make sure the field data and analytical requests were properly saved, field staff should save their work, query the information back into the screen and proofread the values displayed on the screen.

4.1.7.2 Laboratory Data Reduction

The laboratory's goal is to minimize the steps needed to transform raw data into reportable results and maximize on the number of analytical results generated by automated systems. The more automated the data reduction process, the less likely data transcription and calculation errors are to occur.

Laboratory data reduction procedures are discussed in detail in each laboratory QA manual.

4.2 Verification and Validation Methods

The data verification and validation process is designed to ensure that transcription and data reduction errors are minimized, a full and complete data collection record exists and can be produced on demand, the data are actually reviewed, that all variances which affect the data are noted and qualified, and most importantly that any variances or issues which may result in loss of use of data are documented and corrected.

4.2.1 Data Verification

Data verification uses a documented systematic set of assessment requirements, to ensure the data set meets a specified set of criteria as described in the QAPP. Personnel who collected the data perform verification of the data before validating. Supervisors spot check the data to ensure accuracy. This systematic process evaluates data collection performance and compliance against a set of standards for completeness, correctness and consistency.

Field data verification activities include field audits to ensure the following:

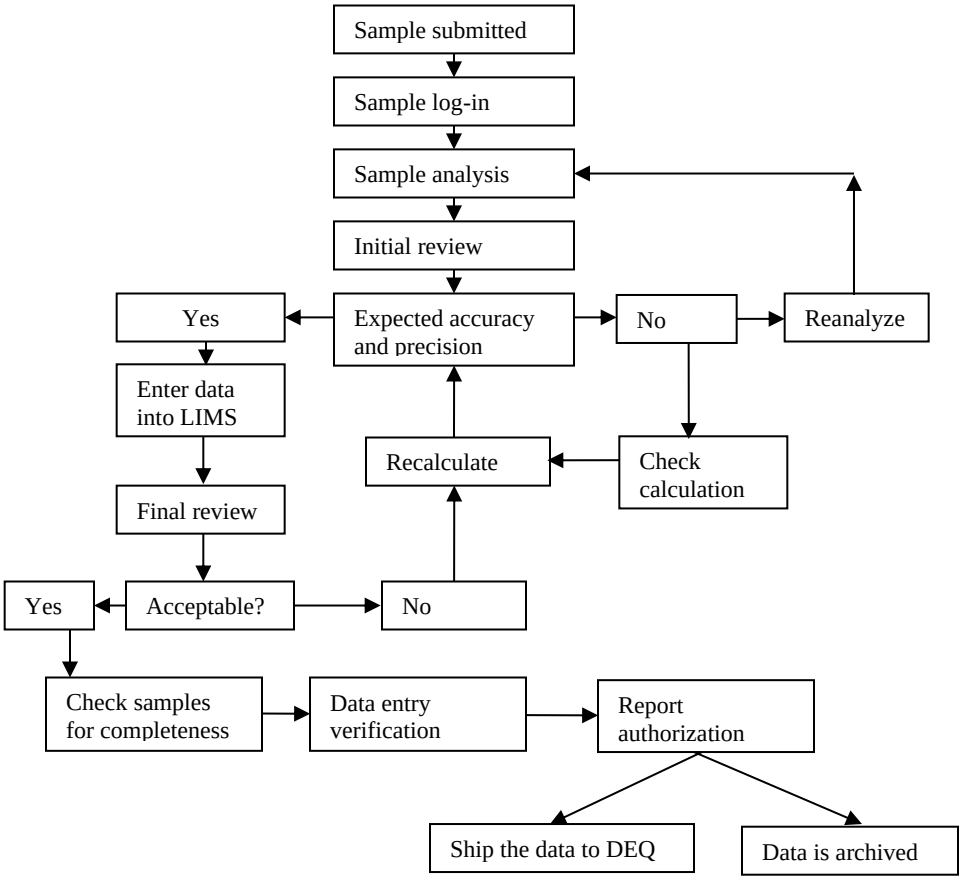
1) The applicable SOPs are followed for sample collection
2) The required number of blanks and splits are collected
3) The field instruments have been calibrated according to the SOPs and documented in the logbook
4) Sample integrity is preserved (sample preservation and handling), and
5) Internal checks are followed to ensure correct data entry.

Figure 4 is shows a flow chart of the analytical data verification process. Data verification is the routine laboratory process through which proper quantification, recording, transcription, and calculations are confirmed. It also confirms that the data is reasonable and complete. The process should be such that errors are minimized and that corrective action steps are taken and documented when errors are detected. The objective of data verification is to provide results of verifiable and acceptable quality whose validity is not jeopardized. The data verification process ensures that:

- The correct samples are reported;
- There were no systematic errors in calculating final results;
- Samples were analyzed within calibration and required holding times;
- The quality control elements monitored were within known acceptance limits.

Each analyst and/or technician is responsible for ensuring that the results of each analytical determination have all associated QC measurements (completeness) and that the acceptance criteria are met and documented according to the protocol (correctness). The analyst and/or technician is responsible for checking calculations, completing sample preparation, calibration, analysis, standard and instrument logs. The Senior Chemist is responsible for reviewing this work for completeness and correctness prior to authorizing the individual results for release. This includes checking for appropriate flagging of final results. Any discrepancy will initiate a recheck of data or reanalysis of the samples.

Figure 4: Analytical Data Verification Processes



4.2.1 Data Validation

Data validation is a process of verifying that qualitative and quantitative information generated relative to a given sample is complete and accurate. Data validation process shall be performed for both field and laboratory operations as described below:

4.2.2.1 Field Data Validation Process

Processes to evaluate field data for this program primarily include reviewing field data sheets to check for transcription errors by the field staff and field quality control data. These procedures are performed to ensure that field measurements were collected properly and documented. The field data documents includes data generated during measurement of field parameters, observations of sampling conditions, results of any quality control sample analyses, and field instrument calibrations. This task will be the responsibility of WQM QA Coordinator who will not participate in making any of the field measurements.

The number and type of field QC samples should comply with program objectives. Field QC samples provide information to the QA Coordinator about sampling conditions, sampling techniques, field precision and sample homogeneity. The QC coordinator confirms that field QC samples were sent to the laboratory at the required frequency.

4.2.2.2 Laboratory Data Validation Process

The Laboratory Data Validation should include the following:

1. A review of the data and all the information associated with its collection to be sure that all required documents and form were filled out correctly and completely.
2. Verification that all field quality control samples were taken at the frequency specified by the program DQOs and submitted for analysis.
3. A check to ensure laboratory quality control objectives were met and results were reported. Items to be verified include holding times, sample preservation and storage, sampling techniques, QC sample results (duplicates, spikes, blanks).
4. An examination of the raw data and verification of calculations and an examination of about 10% of all raw data for transfer accuracy. If errors are identified, another 10% of the raw data must be examined.
5. An examination of the raw data for very high or very low values, or unexpected values which may result from misplaced decimal points, transcription errors, rounding errors or instrumentation malfunction.

Data qualifier codes will be applied to those sample results that fall outside of QC acceptance criteria. An explanation of data qualifier codes is provided in Appendix B.

CEDS database has been programmed with the capability to screen the data. The automated screening process occurs during data entry and analytical data uploads validating field data entry, analytical results, and QC sample results by identifying outliners based on the acceptable limits. Data failing to meet the criteria are flagged in a valid value field and/or written to an error report to alert the data users. The data users should validate the data before the data is assessed (see Figure 5).

4.2.2.3 Data Entry Screen

The data entry screen has built in checks for valid station identifications, sampling run ID, laboratory service requests, collector’s initials, and range checks for field measurements.

4.2.2.4 Analytical Data Screen

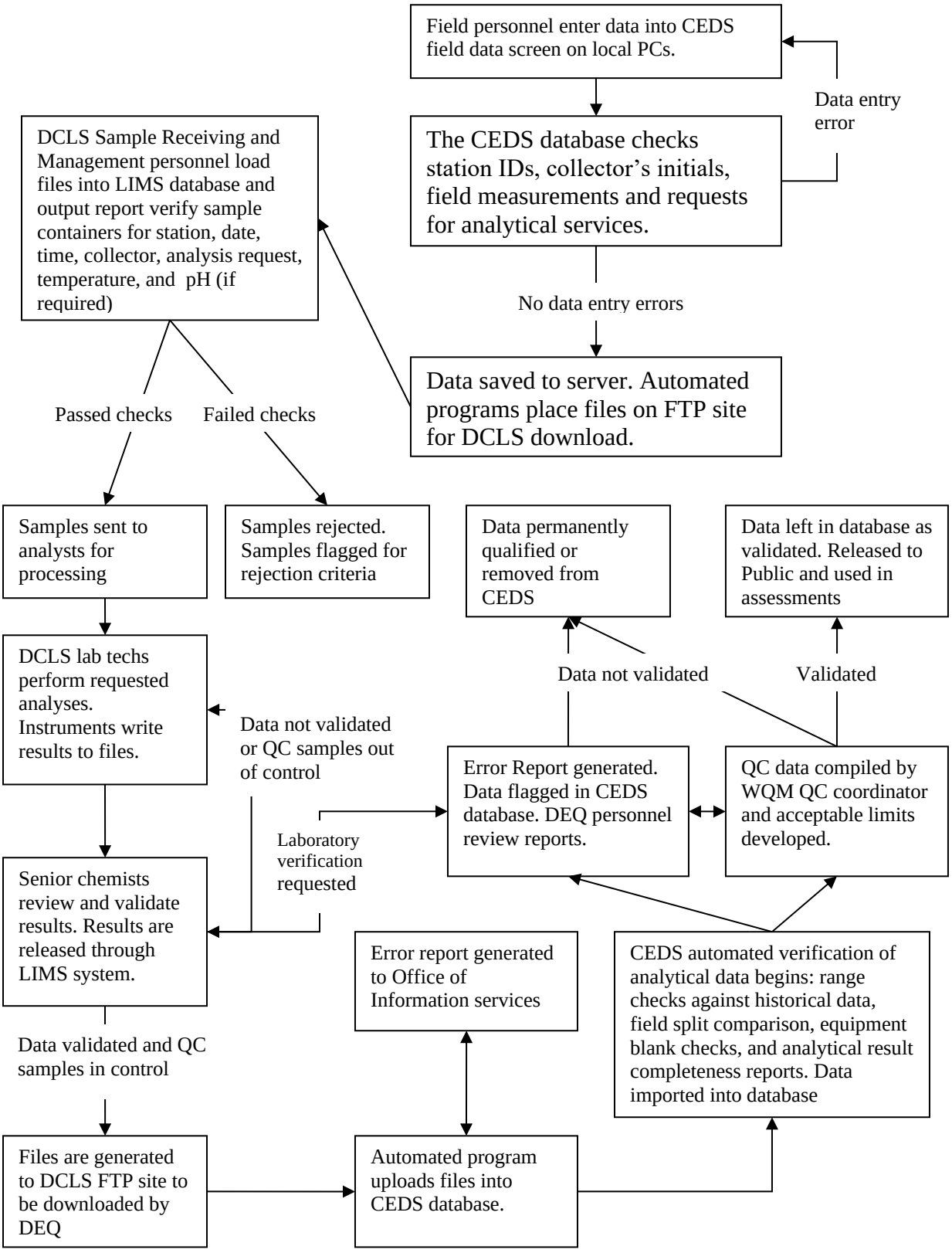
Data limits have been established for each parameter based upon analytical reporting limits as an initial screening tool. These limits are used to identify outliners based upon data, which are within the defined detection limit for each parameter. Upper limits have been set for those parameters such as pH analyses where analytical methods define an upper detection limit. In

addition, a “parts < whole” check is performed on the data where fractions and total parameter determinations are made, such as for solids analyses.

4.2.2.5 Historical Data Range Checks

For the historical screening, parameter limits have been established using historical ambient data. Each analytical result is compared to a historical high and low criteria based on all the historical values available for the sample collection site, depth and month of collection. When a site has less than 12 samples, the values are compared to high and low generic values for the analyte based on the entire available data set for that parameter. Ranges of data variation will be further demarcated using relevant geographic and environmental considerations and appropriate statistical analysis. Any data outside of the historical ranges are flagged for additional review based on available calibration log and other QC documentation. If the data is found to be invalid it is flagged.

Figure 5: Flow Chart of CEDS Data Validation Process



4.2.2.6 Quality Control Sample Screening

For key parameters of interest, 4% of the total annual station samples submitted to DCLS will be quality control samples (equipment blanks and field splits). Results from these quality control samples will be used to establish control limits for the validation system. DEQ implemented system of generating QC samples in 1999. Because of the volume of data generated since that time, a program has not yet been developed in CEDS to validate these data in their entirety. Currently the CEDS database compares replicate results against each other to ensure they are within 5% of each other. Equipment blank results are compared to the analytical MDLs reported by DCLS to produce an error report for any values that exceed the analytical MDL. The WQM QA coordinator periodically reviews these reports and provides a summary of the findings to the regional WQM managers who are then required to review and request laboratory verifications if necessary and give a response to the WQM QA coordinator on their findings as appropriate. Data in the database are then flagged, removed or validated based on the response.

As an additional QC check, the WQM QA coordinator utilizes statistical analyses to develop an acceptable range of parameter variation for field blanks and field splits based on the range of results for the entire agency. For split samples, the precision can be expected to vary with concentration. Results are reviewed for the presence of developing trends which may be indicative of procedural error. If the presence of a trend is detected the affected region is notified and a corrective action is implemented to find and eliminate the source of error.

4.3 Reconciliation with User Requirements

Samples collected and correctly analyzed will subsequently be assessed for possible inclusion in the Integrated 303(d)/305(b) Report, TMDL development, permit decisions or other purposes. One of the main objectives of WQM is to use the generated data to determine the percentage of stream segments with water quality standard violations. If the data from a sampling station shows an exceedance of applicable water quality standards for the conventional pollutants in more than 10.5% of the samples collected, the segment may be subjected to impairment listing for the identified pollutant(s). Additional information can be found in the latest WQA Guidance Manual available at https://www.deq.virginia.gov/our-programs/water/water-quality/assessments/wqa-guidance-manual.

In general, WQM data rejected during laboratory analysis or during the data validation process are not quality assured and thus not considered for assessment. However, other qualified data not meeting QA/QC requirements may be used for listing or delisting waters on the 303(d)/305(b) list or for TMDL development on a case by case basis provided the potential uncertainties associated with the data are addressed and the appropriate caveats are documented.

Appendices

Appendix A: Corrective Action Request (CAR) Form

Corrective Action Request Form

Section I: to be completed by originator
Submitted by: _____ Date: _____

A. Nature of Problem:

B. Possible Cause:

C. Date of Problem Identified: _____

D. Samples That May Be Invalid:

E. Recommended Corrective Action (Optional):

Continued on next page

Corrective Action Request Form- Continued

Section II: to be completed by program manager
Name: _____ Date: _____

A. Recommended Corrective Action:

B. Follow Up Action Required:

C. Implementation Will Begin On:

Section III: to be completed by QA Officer
Name: _____ Date: _____

A. Recommended Corrective Action:

B. Follow Up Action Required:

C. Implementation Will Begin On:

Appendix B: Data Qualifier Codes

Code	Description
$	Calculated by retrieval software. Numerical value was neither measured nor reported to the database, but was calculated from other data available during generation of the retrieval report.
*	One of multiple sample bottles not received
<	Value less than the number reported.
<PE	Value less than the number reported. Sample improperly preserved.
>	Value greater than the number reported but unknown.
A	Value is the mean of two or more determinations.
B	Results based upon colony counts outside acceptable range of 60 cfu specified by the method.
BL	Bacterial counts out of range high and exceed 80 CFU.
BQ	Sample analyzed beyond holding time and sample results are higher than method's specified limit of 60 cfu.
C	Calculated. Value stored not measured directly.
CAB	Algal bloom, no sample taken.
CAS	Algal sample taken.
CBF	Biofouling.
CDB	Disturbed bottom.
CFK	Fish kill.
CLF	Low flow.
CMS	Confirmed by Mass Spec.
CRS	CAN'T REMEMBER SHIT
CSC	Site location change.
CSW	Salinity level calibrated incorrectly.
CTC	Time change.
CTF	Temperature probe failure.
CTS	Time skip.
CTW	Turbid water.
CWD	Instrument at wrong depth.
D	Field measurement.
E	Extra sample taken in compositing process.
F	In the case of species, F indicates female.
FO	Value is not valid.
G	Value is the maximum of the two or more determinations.
GBO	Blocked optic.
GNV	Negative value.
GPC	Post calibration out of range.
GPF	Probe failure.
GSC	Seal compromise.
GWL	Wiper lost.
GWM	Wiper malfunction.
H	Value based on field kit determination; may not be accurate.
I	STORET CONVERSION
IF	Possible analyte interference not confirmed as substance.
J	Estimated. Value is not result of analytical measurement.
JB	Compound was found in the blank and sample. Result is less than the RL but greater than or equal to the MDL.
K	Off-scale low. Actual value not known, may indicate failure to detect substance.
L	Off-scale high. Actual value not known, but known to be greater than value shown.
LB	Bacterial counts out of range high and exceed 80 CFU.
LP	Off-scale high. Too numerous to count. Actual value not known, but known to be greater than value shown.
LQ	Off-scale high. Actual value not known, but known to be greater than value shown. Sample processed beyond holding time.
LS	Calibration drift for LI-COR deck sensor is greater than or equal to 10% since its purchase or most recent recalibration.
LU	Calibration drift for LI-COR underwater sensor is greater than or equal to 10% since its purchase or most recent recalibration.
M	Presence of material verified, but not quantified. Indicates a positive detection, at a level too low to permit accurate quantification. In the case of temperature or oxygen reduction potential, M indicates a negative value. In the case of species, M indicates male sex.

Code	Description
MD	Less than the MDL as calculated by 40CFR136.
MT	Presence of material verified, but not quantified. Value reported is less than the criteria of detection.
N	Presumptive evidence of presence of material.
ND	non detect
NIR	Instrument removed.
NIS	Incorrect instrument setup. QUALITY CONTROL FAILURE. DATA NOT VALID.
NJ	The analysis indicates the presence of an analyte that has been tentatively identified and the associated numerical value represents its approximate concentration.
NND	No data.
NNF	Ram clogged, no flow.
NOW	Instrument out of water.
NPF	Power failure.
NQR	Data rejected due to QA.
O	Sampled for, but analysis lost. Accompanying value is not meaningful for analysis.
P	Too numerous to count.
PDP	DO poisoning (anoxia).
PE	Sample Improperly Preserved
PSW	Salinity calibrated to incorrect level.
Q	Sample held beyond normal holding time.
Q1	Quality Control Sample: Recovery greater than acceptance criteria. Sample results biased high.
QF	QUALITY CONTROL FAILURE. DATA NOT VALID.
QFQ	Quality control failure. Sample analyzed beyond holding time.
QFT	Sample received above 4 deg C. Analyte detected above the MDL but below the method quantification limit.
QQ	Analyte detected above the MDL but below the method quantification limit.
QQQ	Sample beyond hold time. Analyte detected above MDL below RL.
QT	Sample held beyond normal holding time, value reported is less than the criteria of detection.
QU	Sample held beyond normal holding time, material was analyzed for, but not detected. Value stored is the limit of detection for the process in use.
R	Significant rain in the past 48 hours.
RR	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.
S	Laboratory test.
T	Value reported is less than the criteria of detection.
TPE	Value reported is less than the criteria of detection. Sample improperly preserved.
TQF	Sample received above 4 deg C. Analyte detected above the MDL but below the method quantification limit.
U	Material analyzed for, but not detected. Value stored is the limit of detection for the process in use. In the case of species, undetermined sex.
UIF	Material analyzed for, but not detected. Value stored is the limit of detection for the process in use. In the case of species, undetermined sex. Matrix interference.
UJ	The analyte was not detected above the reported sample quantification limit. However, the reported quantification limit is approximate and may or may not represent the actual limit of quantification necessary to accurately and precisely measure the analyte in the sample.
UPE	Value less than the number reported. Sample improperly preserved.
UQ	Sample held beyond normal holding time, material was analyzed for, but not detected. Value stored is the limit of detection for the process in use.
UQF	Value reported Is less than the criteria of detection. QUALITY CONTROL FAILURE. DATA NOT VALID.
V	Indicates the analyte was detected in both the sample and associated method blank.
W	Value observed is less than the lowest value reportable under remark "T".
X	Value is QUASI vertically-integrated sample.
Y	Chain of Custody Issue
YQQ	Chain of Custody Issue. Analyte detected above the MDL but below the method quantification limit.
YT	Chain of Custody Issue. Value reported is less than the criteria of detection.
Z	Too many colonies were present to count (TNTC), the numeric value represents the filtration volume.

Appendix C: Parameter Uses and Applicable Criteria

Analyte	Matrix	Applicable Programs (refer to Section 2.10.6 for program definitions)	Data Uses S&T = Status and Trends: WQ DU Assessments = Water Quality Designated Use Assessment; CC= Climate Change ;	Applicable WQ Regulations or Guideline	WQ Criteria
Temperature (deg. C)	Water	All	S&T, TMDL development, WQ DU Assessments, CC	§ 62.1-44.15 of the Code of Virginia; Clean Water Act (33 USC § 1251 et seq.); 40 CFR Part 131; 9VAC25-260-310	Nontidal water 32
					Mountainous Zones 31
					Stockable Trout Waters – 21
					Natural Trout waters 20
Depth	Water	CB, RL, C2	Informational	N/A	N/A
pH (SU)	Water	All	S&T, TMDL development, WQ DU Assessments, CC	§ 62.1-44.15 of the Code of Virginia (WQMIRA); Clean Water Act (33 USC § 1251 et seq.); 40 CFR Part 131	Open Ocean 6.0-9.0
					Tidal Waters in Chowan and Atlantic Basins 6.0-9.0
					Nontidal waters 6.0-9.0
					Mountainous Zones 6.0-9.0
					Stockable Trout waters 6.0-9.0
DO (mg/L)	Water	All	S&T, TMDL development, WQ DU Assessments, CC	§ 62.1-44.15 of the Code of Virginia (WQMIRA); Clean Water Act (33 USC § 1251 et seq.); 40 CFR Part 131; 9VAC25-260-185	Open Ocean min 5.0
					Tidal Waters in Chowan and Atlantic Basins Min 4.0, daily ave. 5.0
					Nontidal waters – Piedmont and Coastal zones min. 4.0 daily ave. 5.0
					Chesapeake Bay and tidal tributaries – Designated uses

					and temporal uses apply (9VAC25-260-185)
					Mountainous Zone waters min. 4.0, daily ave 5.0
					Stockable Trout Waters min 4.0 daily ave 5.0
					Natural Trout Waters min. 6.0, daily ave. 7.0
Specific conductance	Water	All	S&T, TMDL development, WQ DU Assessments, CC	N/A	N/A
Salinity	Water	C2, CB, PE	CC	N/A	N/A
Turbidity	Water	BN, CB, PE	S&T, TMDL development, WQ DU Assessments, SS	N/A	N/A
Alkalinity	Water	AW,BN, FP,TM,TR	S&T	N/A	N/A
Ammonia Nitrogen	Water	C2, CB, FP, RL, SS	S&T, TMDL development, WQ DU Assessments, SS	9VAC25-260-155, 9VAC25-260-310	Various based on water temperature and pH refer to https://law.lis.virginia.gov/admincode/title9/agency25/chapter260/section155/
BOD	Water	FP	TMDL development, WQ DU Assessments	9VAC25-260-310 for Chickahominy; 9VAC25-790-460	6 mg/l monthly average, with not more than 5% of individual samples to exceed 8 mg/L
Chloride	Water	BN, FP, RB, TM, TR	TMDL development, WQ DU Assessments	9VAC25-260-140	Freshwater acute 860,000
					Freshwater chronic 230,000
					Public Water supply 250,000

Chlorophyll a	Water	AW, C2, CB, FP, PE, RL, TR	TMDL development, WQ DU Assessments	9VAC25-260-185	Narrative criteria applicable March 1- September 30
				9VAC25-260-310 (applicable to the James River only)	Various for spacial and season
Chlorophyll a, benthic	water	AL, SS	S&T	N/A	N/A
COD	Water	FP	TMDL development, WQ DU Assessments	N/A	N/A
E. Coli	Water	AW,BN, CB, CM, FP, RL, TR		N/A	N/A
Enterococcus	Water	AW,BN, CB, CM, FP, SS, TR	S&T, TMDL development, WQ DU Assessments, SS	9VAC25-260-160 and 9VAC25-260-170	Geometric Mean 35/100 mL or Single Threshold value <130/and 100 mL
Fecal Coliform	Water	AW,BN, CB, CM, FP, TR	S&T, TMDL development, WQ DU Assessments, SS	9VAC25-260-160, 9VAC25-260-170 and 9VAC25-31-490	Geometric Mean 126/100 mL or Single Threshold value <410/100 mL
Hardness	Water	C2, CB, DR, PE, TR	WQ DU Assessments for Calculation of Metals Criteria	N/A	N/A
Nitrate	Water	BN, FP	TMDL development, WQ DU Assessments	9VAC25-260-350, WQ DU Assessments	Public water supply 10,000
Nitrite	Water	BN, CB, CM, FP	TMDL development, WQ DU Assessments		
Nitrate-Nitrite-N	Water	C2,CB, FP, RL	S&T, TMDL development, WQ DU Assessments, SS	9VAC25-260-350, WQ DU Assessments	Public water supply 10,000
Orthophosphate-P	Water	C2,CB, FP, RL, SS	S&T, WQ DU Assessments (As component of TP), TMDL development	N/A	N/A
Sulfate	Water		TMDL development, WQ DU Assessments		

Total Kjeldahl Nitrogen	Water	BN, PE, RB, TM, TR, TM SS	S&T, WQ DU Assessments (as component of TN)	N/A	N/A
Total Nitrogen	Water	AW,C2, CB, FP, PE, RB, TM, TR, TM, RL, SS	S&T, TMDL development, WQ DU Assessments, SS	9VAC25-260-350, 9VAC25-260-185	
Total Organic Carbon	Water	FP, RB, TM	TMDL	N/A	N/A
Total Phosphorus	Water	AW,C2, CB, CM, PE, RB, TM, TR, RL, SS	S&T, TMDL development, WQ DU Assessments, SS	9VAC25-260-350, 9VAC25-260-185, 9VAC25-260-310	N/A
TSS	Water	AW, BN, C2,CB, CM, PE, TR	S&T, TMDL development, WQ DU Assessments, SS	9VAC25-260-185, 9VAC25-260-310	N/A

Metal Analyses

Analyte	**Matrix**	**Applicable Programs (refer to Section 2.10.6 for program definitions)**	**Data Uses** S&T = Status and Trends: WQ DU Assessments = Water Quality Designated Use Assessment; CC= Climate Change ;	**Applicable WQ Standard**	**WQ Criteria**
Aluminum,dis.	Water	C2, DR, FP, SS, TR, FP	TMDL development, WQ DU Assessments	N/A	N/A
Antimony, dis. ug/L	Water	C2, DR, FP, SS, TR	TMDL development, WQ DU Assessments	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	Public Water Supply 5.6 Human Health 640
Arsenic, dis. ug/L	Water	C2, DR, FP, SS, TR	TMDL development, WQ DU Assessments	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	Public Water Supply 5.6 Human Health 640
Barium, dis	Water	C2, DR, FP, SS, TR	TMDL development, WQ DU Assessments		

Beryllium, dis.	Water	C2, DR, FP, SS, TR	TMDL development, WQ DU Assessments	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	N/A
Bromide, dis.	Water	BN	TMDL development, WQ DU Assessments	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	N/A
Cadmium, dis. ug/L	Water	C2, DR, FP, SS, TR	TMDL development, WQ DU Assessments	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	Freshwater acute 1.8 at CaCO3 of 100
					Freshwater Chronic 0.72 at CaCO3 of 100
					Saltwater acute 33 x WER*
					Saltwater chronic 79 x WER*
					Public water supply 5
Calcium, dis.	Water	BN, C2	TMDL development, WQ DU Assessments	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	N/A
Chromium,dis. ug/L	Water	C2, DR, FP, SS, TR	TMDL development, WQ DU Assessments	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	Public Health 100 Total Chromium
Copper, dis. ug/L	Water	C2, DR, FP, SS, TR	TMDL development, WQ DU Assessments	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	Freshwater acute 13 at CaCo3 of 100
					Freshwater chronic 9.0 at CaCo3 of 100
					Saltwater acute 9.3 x WER*
					Saltwater Chronic 9.3 x WER*
					Public Water supply 1,300
Iron(ICP), dis. ug/L	Water	C2, DR, FP, SS, TR	TMDL development, WQ DU Assessments	9VAC25-260-140 Criterion to maintain acceptable taste, odor, or aesthetic quality of drinking water and applies at the drinking water intake.	Public Water Supply 300
Lead, dis. ug/L	Water	C2, DR, FP, SS, TR	TMDL development, WQ DU Assessments	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	Freshwater acute 94 at CaCO3 of 100
					Freshwater acute 11 at CaCO3 of 100
					Saltwater acute 230 x WER*

					Saltwater Chronic 8.8 x WER*
					Public Water Supply 15
Magnesium (ICP), dis.	Water	BN, C2, DR, FP, SS, TR	TMDL development, WQ DU Assessments	9VAC25-260-140	N/A
Manganese, dis.	Water	C2, DR, FP, SS, TR	TMDL development, WQ DU Assessments	9VAC25-260-140	N/A
Mercury, dis. ug/L	Water	C2, DR, FP, SS, TR	TMDL development, WQ DU Assessments	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	Freshwater acute 1.4
					Freshwater chronic 0.77
					Saltwater acute 1.8
					Saltwater chronic 0.94
Nickel, dis.	Water	C2, DR, FP, SS, TR	TMDL development, WQ DU Assessments, SS	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	Freshwater acute 180 at CaCO3 of 100
					Freshwater acute 20 at CaCO3 of 100
					Saltwater acute 74 x WER*
					Saltwater Chronic 8.2 x WER*
					Public Water Supply 610
					All other surface waters 4,600
Particulate Carbone	Water	C2, CB	WQ DU Assessments, SS	N/A	N/A
Particulate nitrogen	Water	C2, CB	WQ DU Assessments, SS	N/A	N/A
Particulate phosphorus	Water	C2, CB	WQ DU Assessments, SS	N/A	N/A
Potassium	Water	BN, C2, DR, FP, SS, TR, RB, TM, TR	WQ DU Assessments, SS	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	N/A
Selenium, dis.	Water	C2, DR, FP, SS, TR	WQ DU Assessments, SS	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	Freshwater acute 20
					Freshwater acute 5
					Saltwater acute 290 x WER*

					Saltwater Chronic 71 x WER*
					Public Water Supply 170
					All other surface waters 4,200
Silver, dis.	Water	C2, DR, FP, SS, TR	WQ DU Assessments, SS	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	Freshwater acute 3.4 at CaCo3 of 100
					Saltwater acute 1.9 x WER*
Strontium, dis.	Water	C2, DR, FP, SS, TR	WQ DU Assessments, SS	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	N/A
Sulfate, dis	Water	BN, RB, TM, TR	WQ DU Assessments, SS	N/A	N/A
Thallium, dis.	Water	C2, DR, FP, SS, TR	WQ DU Assessments, SS	9VAC25-260-140	Public water supply 0.24
					All other surface water 0.47
Uranium ug/L	Water	DR, SS	SS	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	Public water supply 30
Vanadium, dis.	Water	C2, DR, FP, SS, TR	SS	N/A	N/A
Zinc, dis. ug/L	Water	C2, DR, FP, SS, TR	WQ DU Assessments, SS	9VAC25-260-140; § 62.1-44.15 of the Code of Virginia (WQMIRA);	Freshwater acute 120
					Freshwater acute 120
					Saltwater acute 90 x WER*
					Saltwater Chronic 81 x WER*
					Public Water Supply 7,400
					All other surface waters 26,000
Aluminum	Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	N/A
Antimony	Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	N/A
Arsenic ppm dry weight	Freshwater Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	33
	Estuarine Sediment				70
Beryllium	Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	N/A

Cadmium ppm dry weight	Freshwater Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	4.98
	Estuarine Sediment				9.6
Chromium ppm dry weight	Freshwater Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	111
	Estuarine Sediment				370
Copper ppm dry weight	Freshwater Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	149
	Estuarine Sediment				270
Iron	Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	N/A
Lead ppm dry weight	Freshwater Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	128
	Estuarine Sediment				218
Lithium	Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	N/A
Manganese	Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	N/A
Mercury ppm dry weight	Freshwater Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	1.06
	Estuarine Sediment				0.71
Nickel ppm dry weight	Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	48.6
Selenium	Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	
Silver	Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	N/A
Thallium	Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	N/A
Vanadium	Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	N/A
Zinc ppm dry weight	Freshwater Sediment	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	459
	Estuarine Sediment				410
Aluminum	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	N/A
Antimony ppb wet weight	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	1,600
Arsenic ppb wet weight	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	270

Barium ppb wet weight	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	800,000
Beryllium	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	N/A
Cadmium	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	4,000
Chromium III	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	6,000,000
Chromium IV					12,000
Copper	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	N/A
Lead	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	N/A
Manganese	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	N/A
Mercury	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	300
Nickel	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	220,000
Selenium ppb wet weight	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	20,000
Silver	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	N/A
Thallium	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	54
Vanadium	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	N/A
Zinc	Fish Tissue	FT	WQ DU Assessments, SS	Clean Water Act 106; code of Virginia: Article 1. Section 62.1-44.19:5	1,200,000
*Freshwater values are a function of total hardness as calcium caRB, TM, TRonate (CaCO3) mg/l and the WER. WER = Water Effect Ratio = 1 unless determined otherwise under 9VAC25-260-140 F					
Sediment and Fish Tissue Criterion listed is based on DEQ 2020 Water Quality Assessment Guidance Threshold Values RISK-BASED TISSUE SCREENING VALUE (TSVs) FOR FISH TISSUE UPDATED FROM INTEGRATED RISK INFORMATION SYSTEM (IRIS) FOR GENERAL POPULATION (ADULT) BODY WEIGHT (KG) 70 RISK LEVEL 10-5 CONSUMPTION RATE (KG/DAY) 0.0175					