QUALITY ASSURANCE MANUAL

FOR

[GHANA WATER COMPANY LIMITED]

[28th February Road, Near Independence Square, P. O. Box M 194, Ministries, Accra, Ghana]

MOTTO: "QUANTITY AND PRICE ARE NEGOTIABLE BUT QUALITY AND SAFETY ARE NOT"

APPROVALS

This Laboratory Quality Assurance Manual, documents the Quality Assurance Programme and activities in Ghana Water Company Limited.

The signatures of the Appropriate Authorities below indicate that the manual is being accepted individually and collectively, and that the contents shall be implemented in the daily operational activities of the Water Quality Assurance Department Laboratories' nationwide.

MANAGING DIRECTOR- [ING. DR. CLIFORD A. BRAIMAH] **Date**

CHIEF MANAGER-WQA-[MARGARET N.M. MACAULEY] **Date**

REGIONAL CHIEF MANAGERS- [NAME] **Date**

REG. WATER QUALITY ASSURANCE MANAGER [NAME] **Date**

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1.0 Quality Policy Statement

The quality manual is intended for the laboratories' operations of the Ghana Water Company Limited with its Head Office located at 28th February Road, Near Independence Square, P. O. Box M 194, Ministries, and Accra, Ghana with Ten (10) Regional Laboratories located at the regional capitals in each region of Ghana. The laboratories provide analysis of samples as required by Ghana Drinking Water Standards (Water Quality- Specifications for Drinking Water.). Only the samples required to be analyzed under the GS 175-Ghana Drinking Water Quality standards are covered by this quality system. The Ghana Standard specifies the requirements, methods of sampling and test for drinking water obtained from "prepared waters" or "waters defined by origin". Types of Samples to be analyzed include Raw Water, Treated Water, Distributed Water and Ground Water. The standard also applies to packaged/bottled drinking water

1.1 Ghana Water Company Limited Quality Policy Statement

The Water Quality Assurance Department of Ghana Water Company Limited is committed to its role in providing clean and safe potable water to the urban communities in Ghana and defining acceptable laboratory practices in the quality documentation in such a way so as to ensure compliance with the regulatory requirements. Management's policy is to ensure that the information in the quality documentation is communicated to, understood and implemented by all the laboratory staff performing work in the laboratory. It shall be the policy of Water Quality Assurance Department of Ghana Water Company Limited to conduct all businesses with integrity and in an ethical manner. It is a basic and expected responsibility of each staff member and manager to hold to the highest ethical standard of professional conduct in the performance of all duties.

The quality manual documents the policies and references the procedures used in the laboratory to ensure test data generated for submittal to the Management of Ghana Water Company Limited, Public Utility Regulatory Commission (PURC) and our Clients are scientifically acceptable as defined by the method performance criteria.

The objectives of the Water Quality Assurance Department of Ghana Water Company Limited are to produce data of known and documented quality in order to demonstrate conformance to the laboratory accreditation requirements. The objectives are measured with internal audits and evaluated as part of the management review.

It is a policy of the Water Quality Assurance Department of Ghana Water Company Limited that any subcontracting of work shall be given to laboratories which adheres to high quality standards as verified through their accreditation whenever possible. A chain of custody form is used to track samples to the subcontracted laboratory.

1.2 Vision

To be the best department in GWCL, exhibiting commitment, effectiveness and efficiency.

1.3 Mission

We are committed to employing total quality management, professionalism and innovation for the delivery of adequate quantities of potable water to meet our various consumers' needs.

1.4 Core Values

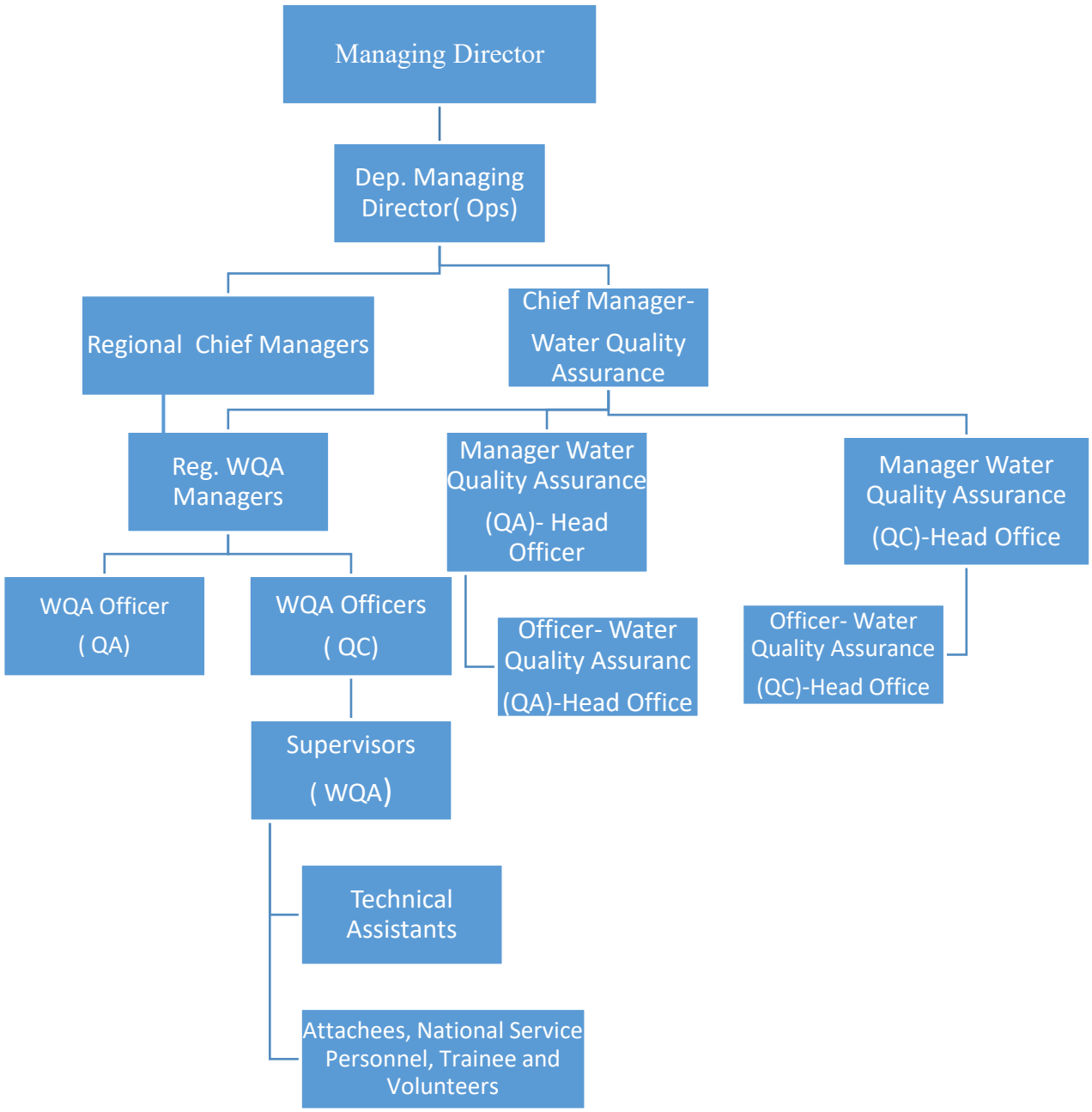
- Professionalism,
- Commitment
- Quality and excellent customer service
- Urgency in service delivery
- Continuous improvement and innovation.
- Health care and safety of stakeholders
- High ethical and professional standards

1.5 MOTTO

"Quantity and price are negotiable but quality and *safety are not"*

2.0 Organization and Management Structure

2.1 Organizational Chart for the Water Quality Assurance Department



NB:

1. **Regional Chief Managers are the representatives of the MD and spending officers in the regions**
2. **The Trainees, Attachees, National Service Personnel and Volunteers are not permanent staff. They perform similar jobs as the technical assistants**

2.2 Management Responsibilities

Management of the Ghana Water Company Limited has the overall responsibility for the management and the authority needed to generate quality operations of all Laboratories (see Attachment 14 for the List of Laboratories). Management includes The Managing Director, The Deputy Managing Directors, Head Office Chief Manager, Regional Chief Mangers, Regional WQA Managers and the Quality Assurance Officers. Detailed roles and responsibilities of each staff are described in table 2.1 below.

2.3 Job Descriptions of Staff Positions for GWCL Water Quality Assurance Department.

Table 2.1: Roles and Responsibilities for Laboratory Operations

Lab* Operations *Activities	***Chief Manager WQA***	***Regional Chief Manger***	***Regional WQA Managers***	***WQA Managers – Head Office***	***WQA Officers(QA)***	***WQA Officers (QC)***	***WQA Supervisors***	***Technical Assistants***	***Attaches, NSP, Trainees &&Volunteers***
Names	*MNM Macauley*	*To be provided for specific labs*	*To be provided for specific labs*	*To be provided for specific labs*	*To be provided for specific labs*	*To be provided for specific labs*	*To be provided for specific labs*	*To be provided for specific labs*	*To be provided for specific labs*
Lab Quality Manual	*Responsible for developing, implementing reviewing and approval of all Laboratory Quality Manuals* NB: The Managing Director also approves/signs all LQMs.	Commits to support implementation of Lab manual and appropriates/rere lease necessary funding	Assist in planning and developing of the Lab Manual, responsible for implementing and reviewing of the Laboratory Quality Manual throughout the regions	*Assist Chief Manager -WQA for developing, implementing reviewing and approval of all Laboratory Quality Manuals*	Responsible for implementing, control and making proposals for a review of Lab Manual *QC Officer also assists in implementation and reviewing of the manual*	Responsible for implementing, Lab Manual and *assists in implementation and reviewing of the manual*	Supervises the proper implementation of the Lab Quality Manuals and carries out specialized analysis' Prepares drafts an initiates revision with assistants Technical Assistants	*Carry out day to day activities based on the approved Lab Quality Manual*	*Carry out day to day activities based on the approved Lab Quality Manual*
SOPs	*Plans, directs* reviews and approves *the development of proper SOPs within the organization*	Commits to support implementation of SOPs and appropriates/rele ases necessary funding	*Responsible for developing, review, implementation of SOPs throughout the region.*	*Assists to Plan, develop and* submits proposals *of SOPs within the organization for implementations*	*Assists in developing, implementation, review, monitoring and making proposals for reviews SOPs along with the Regional Chief Mangers throughout the region.*	*Responsible for , implementation, review, monitoring and makes inputs proposals for reviews of SOPs throughout the region*	*Provides input and supervises implementation of the SOPs. Applies SOPS where necessary Assists to make inputs for reviews*	*Applies the SOPs in the day to day operations of the laboratories*	*Applies the SOPs in the day to day operations of the laboratories*

Lab* Operations *Activities	***Chief Manager WQA***	***Regional Chief Manger***	***Regional WQA Managers***	***WQA Managers – Head Office***	***WQA Officers(QA)***	***WQA Officers (QC)***	***WQA Supervisors***	***Technical Assistants***	***Attaches, NSP, Trainees &&Volunteers***
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Training	*Responsible for the development of requisite training programmes for all staff categories. Identify training needs of all staff* *Ensures documentations are properly done*	Approves and appropriates/releases necessary funding *Ensures proper documentations*	*Identify training needs of all staff and makes inputs for the development of training programmes in the regions Develops regional staff training needs and submits to HR from the national projection*	*Assist to develop of requisite training programmes for all staff categories.* *Also Identify training needs of all staff*	*Assist in identifying training needs, mentors and coaches all staff. Prepares training Schedules and ensures that staff are adequately trained.* *Documents and Keeps records*	*Makes inputs identifying training needs, mentors and coaches all staff. Conduct training for subordinates and ensures that staff are adequately trained*	*Identifies training needs Mentors and coaches subordinates Provides training for technical staff.*	*Mentors and coaches trainees and attaches. Commemorates areas of weakness to supervisors in terms of trainings*	*Makes inputs into the prepared area of training*
	In all cases, staff training and performance is considered complete after the analyst has produced a successful initial demonstration of method capability for the analysis for which he/she is responsible. In addition, acceptable results from a proficiency testing sample or internal blind quality control sample are documented for the analyst								
Data Management	*Plans for development of efficient and effective data management systems. Collate, evaluate and manage data for decision making and policy management*	Appropriates and supports necessary funding	*-Evaluates, verifies and manages data. -Signs the final report. -Communicates information to the CM- WQA and RCM. Prepares and justifies all Regional Budgets (WQA)*	*Assist to Plan for development of efficient and effective data management systems. Collate, evaluate and manage data for decision making and policy management*	*Assist to evaluate and verify data and prepares reports.* *Provides tertiary review of all data*	*Generates data and prepares reports.* *Provides secondary review of all data*	*Assist to Generate , Compiles and enters data into data management systems Provides secondary review.*	*Assist to generate and records data in accordance with standard procedures Reviews and validates data*	*Assist to generate and records data in accordance with standard procedures as per training*

Lab* Operations *Activities	***Chief Manager WQA***	***Regional Chief Manger***	***Regional WQA Managers***	***WQA Managers – Head Office***	***WQA Officers(QA)***	***WQA Officers (QC)***	***WQA Supervisors***	***Technical Assistants***	***Attaches, NSP, Trainees &&Volunteers***
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Analytical Methods	*Strategizes, plans and develops procedures for the budgeting, procurement and replenishment of stocks*	Commits to, appropriates and releases necessary funding	*Ensure proper implementation of approved Analytical methods (stated references) throughout the region in accordance with the Quality Assurance Manual*	*Assist to Strategize, plans and develops procedures for the budgeting, procurement and replenishment of stocks*	*Monitors and brings up proposals for consideration for reviews of the Analytical Methods*	*Responsible for implementation Analytical Methods* *Also Monitors and makes inputs for consideration for reviews of the*	*Supervises all analysis done in the Laboratory in accordance with the approved Analytical Methods. Keeps track/records of stock usage*	*Carry out analytical tests in accordance with the approved analytical methods and keeps records.* *Maintains information flow on reagent usage*	*Follows training programme in this regard.*
Instrument Maintenance/ Calibrations	*Responsible for robust QA program that includes routine instrument maintenance/calibration*	Commits to, appropriates and releases necessary funding	*Prepares Maintenance/Calibration programme in line with QA programme.* *Ensures consistent instrument maintenance /calibration practices throughout Region*	*Responsible for robust QA program that includes routine instrument maintenance/calibration*	*Reviews maintenance /calibration for completeness and adherence to QA program required and tracks implementation*	*Responsible maintenance /calibration of lab equipment for completeness and adherence to QA program required and tracks implementation*	*Supervisor, implements programme and Reviews maintenance/calibration procedures and record keeping*	*Performs instrument maintenance /calibration and keeps records*	*Follows training programme in this regard.*

Lab* Operations *Activities	***Chief Manager WQA***	***Regional Chief Manger***	***Regional WQA Managers***	***WQA Managers – Head Office***	***WQA Officers(QA)***	***WQA Officers (QC)***	***WQA Supervisors***	***Technical Assistants***	***Attaches, NSP, Trainees &&Volunteers***
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Reagents/supplies	*Strategizes, plans and development procedures for the budgeting, procurement and replenishment of stocks*	Commits to, appropriates and releases necessary funding	*Puts measures in place for stock controls, budgeting, procurement to replenish stocks* *Follow budgetary procedure and prepares regional budget.* *Regional all regional stocks*	*Assist to Strategize, plans and development procedures for the budgeting, procurement and replenishment of stocks* Maintain records and data base on all budgets and procurements	*Manages stocks and keeps good records, updates inventory list Responsible for proper and safe storage of reagents* *Tracks usages of regional stock of all lab reagents for analytical methods*	*Assists Manages stocks and keeps good records, updates inventory list Responsible for proper and safe storage of reagents* *Assists Tracks usages of regional stock of all lab reagents for analytical methods*	*Provide adequate lead-time for re-stocking of inventory. Ensure proper and safe storage of reagents.* *Updates registers and tally cards available regularly* *Reviews stock records and prepares reports for WQA Officer's attention*	*Maintain records of quantity of reagents and laboratory supplies available and provide adequate lead-time for re-stocking of inventory. Ensure proper and safe storage of reagents Updated registers and tally cards available*	*Follows training programme in this regard.*

Lab* Operations *Activities	***Chief Manager WQA***	***Regional Chief Manger***	***Regional WQA Managers***	***WQA Managers – Head Office***	***WQA Officers(QA)***	***WQA Officers (QC)***	***WQA Supervisors***	***Technical Assistants***	***Attaches, NSP, Trainees &&Volunteers***
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Internal QA Audits and Reviews *NB: Two* teams of internal are to be constituted (Northern and Southern sector teams respectively) led by a Quality Assurance Officer/Manager from the head office. The composition of the Audit teams should not include personnel from the laboratory being audited. Frequency of Audit is once a year.	*. Implements annual internal audit for the Ghana water company Limited*	Commits to, Supports , appropriates and releases necessary funding	*Responsible for ensuring that internal audit is implemented in their region. Responsible for corrective action to be implemented in their region*	*Responsible for initiation of existing internal QA Audits, reviews result for all laboratory testings.* *Assist to Implements annual internal audit for the Ghana water company* *Responsible for preparation of QA Audits programme and generates departmental audits reports*	*Makes regional data available for Internal Audits and reviews and schedules Audits* *Implement outcome of Internal audits and reviews. Ensures that corrective action are implemented* *Reviewing and approving any changes to the quality manual and associated quality documentation.* *Responsible for preparation of QA Audits programme and generates departmental audits reports*	*Implement outcome of Internal audits and reviews. Ensures that corrective action are implemented* *Assists to Review any changes to the quality manual and associated quality documentation.*	*Implement outcome of Internal audits and reviews Oversee that the corrective action is in place*	*Implement outcome of Internal audits and reviews and corrective actions from audits reports/findings*	*Follows training programme in this regard.*
QA/QC programmes	*Responsible for policy formulation and implementation which result in quality data generation for all laboratory testing. Ensures that the staff are aware of QA management*	Commits to, appropriates and releases necessary funding	*Responsible for ensuring that existing QA/QC requirements are performed in the laboratory. Verify reports of the QA Manager to ensure data submitted to QA officer meet quality requirement*	*Assists for policy formulation and verifying that existing QA/QC requirements are implemented which result in quality data generation for all laboratory testing.*	*Initiates and ensures QA/QC requirements in the laboratory.*	*QC Officer Carries-out the QC activities in the laboratory*	*Assists to Carry-out the QA/QC requirements in the laboratory*	*Performs the QA/QC requirements of the lab*	*Assist to Perform the QA/QC requirements of the lab as per training*

Lab* Operations *Activities	***Chief Manager WQA***	***Regional Chief Manger***	***Regional WQA Managers***	***WQA Managers – Head Office***	***WQA Officers(QA)***	***WQA Officers (QC)***	***WQA Supervisors***	***Technical Assistants***	***Attaches, NSP, Trainees &&Volunteers***
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Proficiency Examination (PE)/Blind Samples (the frequency of participating in the PT or blind samples is two times per year). **NB: Must be incorporated into QA/QC activities**	*Directs the laboratories on the use of internal and external PE/blind samples*	Commits to, support appropriates and releases necessary funding to ensure implementation	*Responsible for implementing the analysis of internal and external PE/blind samples*	*Assist to ensure all the laboratories use internal and external PE/blind samples*	*Ensures that staff performs analysis of internal and external PE/blind samples*	*QC Officer Supervises/carries out the analysis of internal and external PE/blind samples* Identifies where to get PT samples and to place the order if you need to buy them	*Supervises/carries out the analysis of internal and external PE/blind samples*	*er forms the analysis of internal and external PE/blind samples*	*Assists to Perform the analysis of internal and external PE/blind samples*
Complaint management (the turnaround times for responding back to complaints should be two days after investigations)	*Sets up policy/direction on protocols for complaints/feedback for Ghana water company. Tracks complaints/feedback.*	Commits to, appropriates and releases necessary funding implementation. Uses reports for decision making	*Responsible for handling complaints and feedback on the laboratory report/data*	*Assist Sets up policy/direction on protocols for complaints/feedback for Ghana Water Company Ltd. Ensures Tracking of complaints/feedbacks are implemented*	*Assigned to investigate complaints/feedback and promptly investigates all areas of activity and responsibility involved. Documents complaints/responses*	*Assists to investigate complaints/feedback and promptly investigates all areas of activity and responsibility involved. Documents complaints/responses*	*Assists in handling the complaint and investigation.*	*Assists in handling the complaint and investigation.*	*Observes how complaints are managed*
Health and Safety Issues	*Responsible for formulation of Health, and Safety and Environmental and waste management policies*	Ensures Funds and logistics are available for implementation	*Plans, Budgets and ensures Implementation*	*Assists for formulation of Health, and Safety and Environmental and waste management policies*	*Ensure Health, and Safety and Environmental and waste management policies procedures are followed and adhered to*	*Assists Ensure Health, and Safety and Environmental and waste management policies procedures are followed and adhered to*	*Supervisors and carry out health and safety practices*	*Observe all health and safety practice in carrying out duties*	*Observe all health and safety practice in carrying out duties*

2.4 Personnel Qualifications

A. Chief Manager-Water Quality Assurance

- Must Have MSc qualification in Chemistry, Science Laboratory Technology, Biochemistry, Microbiology, and Environmental Science or other relevant fields in the Sciences.
- 12 years post qualification experience in Laboratory, Quality Assurance/Control management and practices
- Membership of a recognized professional association

B. Water Quality Assurance Manager (Head Office)

- Must Have MSc/BSc qualification in Chemistry, Biochemistry, Science Laboratory Technology Microbiology, Chemical Engineering, Environmental Science or any other relevant fields in the Sciences
- 8 years post qualification experience in Laboratory, Quality Assurance/Control management and practices
- Membership of a recognized professional association

C. Regional Water Quality Assurance Managers

- Must Have MSc/BSc qualification in Chemistry, Biochemistry, Microbiology, Science Laboratory Technology, or Chemical Engineering Environmental Science or and other relevant fields in the Sciences
- 5 years post qualification experience in Laboratory, Quality Assurance/Control management and practices
- Membership of a recognized professional association

D. Water Quality Assurance Officer

- Must Have BSc /HND qualification in Chemistry, Biochemistry, Microbiology, Science Laboratory Technology or Chemical Engineering or any other relevant fields in the Sciences
- 4 years post qualification experience in Laboratory, Quality Assurance/Control management and practices
- Membership of a recognized professional association

E. **Water Quality Assurance Supervisor**

- Must possess at least a Higher National Diploma in Science Laboratory Technology Certificate in Laboratory Technology , Senior Secondary School Certificate Examination or West African Council Certificate Examination (SSSCE/WACCE) in the Sciences or completed Weija Training School for 2 years
- 10 years Post qualification experience in Laboratory, Quality Assurance/Control

management and practices
- Promotion to the Senior Superior position requires at least 3-4 years' service on the grade of supervisor

F. Technical Assistants
- Must possess at least Science Laboratory Technician Certificate, SSSCE/WACCE in the Sciences or completed Weija Training School for 2years
- Basic knowledge/skills in Laboratory, Quality Assurance/Control practices is required

2.5 Identification of Approved Signatories

The following individuals are authorized to sign laboratory reports:
- Regional Water Quality Assurance Manager
- Quality Assurance Officer can sign in the absence of the Regional Water Quality Assurance Manager or when he/she is in acting position (See attachment 1)

3.0 Document Control

All internal regulatory documentation, standard operating procedures, work instructions, service manuals, worksheets, Complaint forms, Clients receipt forms, Laboratory Quality Manuals, logbooks and product instructions that have received the required approvals and are in use in the various laboratories. These are managed and by the **Water Quality Assurance Managers** for all regional and system Laboratory. The Water Quality Assurance Officer is responsible for the day-to- day document control system and keeps a master list of the location of all documents and their current revisions (See Attachment Table 9). The Regional Water Quality Assurance Manager and the Water Quality Assurance Officer approve all SOPs and analytical methods

To access any specific document, an approval must be sought from the Water Quality Assurance Officer. Name of staff making the request, Date and time of request and signature must properly be documented. The Water Quality Assurance Officer must counter sign to indicate that the document has been issued or returned (See attachment 2: Document Control form). All Laboratories are required to draft their SOPs for methods, equipment and document controls (See Table 7.1)

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4.0 Complaints

Every Laboratory has complaint forms and files are maintained in the laboratory. All complaints about the laboratory's activities are documented in a complaint file maintained in the laboratory.

All Complaints must be addressed to and received by the Regional Water Quality Assurance Manager. The Quality Assurance Officer is assigned to investigate complaints and promptly investigates all areas of activity and responsibility involved. Investigation into complaints must be initiated within 24 hour of receiving the complaints. The written results of the investigation including actions taken by the laboratory are reviewed by the Regional Water Quality Assurance Manager. The results of the investigation are signed and dated by the Regional Water Quality Assurance Manager. The outcome of the investigations must be communicated to the complainant when two days after the investigation.
(See attachment 3: Complaints form)

5.0 Departures from documented policies and procedures or from standard specifications

The Chief Manager Water Quality Assurance has the responsibility for ensuring adherence to documented policies and procedures in all laboratories in the organization. However, in the various regions, the Regional Water Quality Assurance Managers are mandated to ensure implementation documented policies and procedures in their respective laboratories with the collaboration of the Regional Chief Manager. SOPS for known/unknown and controlled departures from documented policies and procedures shall be approved by the Chief Manager Water Quality Assurance and allowed when they occur as or when the need arises.

Departures from documented policies and procedures can be planned or unplanned. The departure will be fully documented stating the reasons that necessitated the departure; the affected SOP(s), the intended results of the departure and the actual results obtained.

Departures may include events such as: equipment failure (down times), sample contamination, inadequate sample volumes, unavailability of standard reagents etc.

On the other hand when an unplanned departure occurs, the analyst will be allowed to carry out the analysis but the results obtained and the procedure shall be audited by the Quality Assurance Officer and approved by the Regional Water Quality Assurance Manager and duly documented.

If there are adverse findings in the reports generated for internal use or data reported to the client, the authorities or client will be notified in writing. The procedure used to document any specific departure shall be the same as the corrective action procedure.

6.0 Corrective Action

Corrective actions are actions taken to address concerns regarding work performed by Ghana Water Company Limited laboratories. They come up as a result of detected problems such as nonconformance to documented policies and procedures in an operational laboratory and may be detected by clients, laboratory personnel, assessors or any person or an external organization. Records of the concerns, nonconformance or complaints and subsequent corrective actions are to be maintained (see table 6.1).

The Water Quality Assurance Officer is responsible for assessing each Quality Control Data type. The Regional Water Quality Assurance Manager is responsible for initiating or recommending corrective actions

The laboratory takes corrective action whenever unacceptable conditions exist or departures from documented policies and procedures occur. The following indicators are used to determine unacceptable conditions:

- *QC samples outside the established acceptance criteria*
- *Calibrations outside acceptable criteria*
- *Equipment failure*
- *Proficiency Test studies outside acceptable limits*
- *Non-conformance identified during internal reviews*
- *Non-conformance identified during on-site inspections*
- *Non-conformance or problems identified after receiving a question or complaint*

TABLE 6.1 : SPECIFIC CORRECTIVE ACTIONS

TYPE OF COMPLAINTS	RECOMMENDED ACTION	DOCUMENTATION	DATE
Contaminated Method Blank (Chemistry)	1. Re-analyze blank. 2. Determine source of contamination. 2. Eliminate source of contamination. 4. Prepare new blank 5. Reorder blank	Work sheet/log book	
Lab. Control Samples (LCS) outside acceptance limit (Chemistry)	1. Check preparation log for errors 2. Check analysis for errors 3. Check calculations 4. Re-analyze standard and affected samples 5. Re-prepare standard or use a different standard 7. Reorder laboratory control samples 8. Check reliability of equipment (MDL, Calibrations)	Work sheet/log book	
Failure of Positive control (contamination or lack of appropriate test results) Failure of Negative control (contamination of media) (Microbiology)	1. Check expiration date of the media 2. Check media preparation 3. Check Sterilization Procedures 4. Confirm incubator temperatures 5. Prepare new media from same lot. If still not acceptable, prepare new media from different lot 6. Examine analytical technique Use new positive control culture 7. Reorder microbial media	Work sheet/log book	
Analyst Biases /Errors (All methods)	1. Check data sheet 2. Provide additional training 3. Demonstrate performance of task 4. Analyze a PE sample	Analyst training file Work sheet/log book	
Complaints on doubtful results from clients (Chemistry)	1. Check work sheet or logbooks, for data entry, calibrations 2. Check LCS 3. Check analytical/Method procedures 4. Check equipment reliability 5. Re-analyze samples 6. Resample 7. maintenance and first 8. Retrain analyst	Work sheet/log book	

Complaints on Doubtful results from clients (Physicals)	1. Check work sheet or logbooks 2. Check LCS 3. Check analytical/Method procedures 4. Check equipment reliability 5. Re-analyze samples 6. Re-sample 7. Replace Equipment 8. Retrain analyst	Work sheet/log book	
Complaints on Doubtful results from clients (Microbiology)	1. Check sample handling records 2. Check expiring date for media 3. Check media preparation records, including positive/negative control results 4. Check Sterilization Procedures 5. Confirm incubator temperatures 6. Examine analytical technique 7. Re-order microbial media	Work sheet/log book	

Once an unacceptable condition is identified, the laboratory investigates the problem and outlines a corrective action plan. The Corrective actions are outlined in the following table (Table 6.1):

7.0 Records Management

All Ghana Water Company Laboratories must operate a record management system that allows the historical reconstruction of all laboratory activities. Each laboratory shall keep a record of each activity for a specific period as required by regulation.

Each laboratory maintains the records outlined in the table below:

TABLE 7.1: RECORDS MANAGEMENT

Type of records	***Records Management Procedures***					
	Initiator	***Duration***	***Mode of storage***	***How correction are made***	***Data Management Officer***	***Document Disposal***
Personnel records	*RWQAM*	*Period of stay 0f staff in Ghana Water Company Ltd*	*Electronic Records: Data management system with restricted access with back ups* *Paper Records : Stores in files and cabinets with Restricted Access*	*As and when appraisals are done, upgrading of personnel and Proficiency Tests conducted*	*Human Resources Manager and QA Officer*	*Archives*
Raw data (Bench work data)	*Supervisor*	*1 Year*	*Paper Records : Stored in Files and cabinets in a data maagenet room*	*Initiated by WQA officer and approved by RWQAM*	*Quality Assurance Officer*	*Incineration /recycling*
Sample tracking forms	*WQA Officer*	*Minimum of 2yrs*	*Paper Records : Stored in Files and cabinets*	*Initiated by WQA officer and approved by RWQAM*	*Quality Assurance Officer*	*Archives*
Maintenance records of existing laboratory equipment	*QA Officer*	*Equipment's life span*	*Paper Records : Stored in Files and cabinets*	*Initiated by WQA officer and approved by RWQAM. Regular updates (eg. Cal. Curves, servicing information etc)*	*Quality Assurance Officer*	*Incineration /recycling*
Reports of analysis	*RWQAM*	*Minimum of 10yrs*	*Electronic Records: Data management system with restricted access with back ups* *Paper Records : Stores in files and cabinets with Restricted Access*	*Initiated by WQA officer and approved by RWQAM*	*Quality Assurance Officer*	*Archives*
Log Books	*QA Officer*	*Minimum of 10yrs*	*Paper Records : Stores in files and cabinets with Restricted Access*	*Initiated by WQA officer and approved by RWQAM*	*Quality Assurance Officer*	*Archives*
Complaints	*QA Officer*	*Minimum of 10yrs*	*Electronic Records: Data management system with restricted access with back ups* *Paper Records : Stores in files and cabinets with Restricted Access*	*Initiated by WQA officer and approved by RWQAM*	*Quality Assurance Officer*	*Archives*

Internal Audit reports	*QA Officer*	*Minimum of 10yrs*	*Electronic Records: Data management system with restricted access with back ups* *Paper Records : Stores in files and cabinets with Restricted Access*	*Initiated by WQA officer and approved by RWQAM.* *Must be updated when internal audits are conducted*	*Quality Assurance Officer*	*Archives*
Monthly reports (Raw, Treated and Distributed Water)	*RWQAM*	*Minimum of 10yrs*	*Electronic Records: Data management system with restricted access with back ups* *Paper Records : Stores in files and cabinets with Restricted Access*	*Initiated by WQA officer and approved by RWQAM*	*Quality Assurance Officer*	*Archives*
Laboratory Safety reports	*QA Officer*	*Minimum of 10yrs*	*Electronic Records: Data management system with restricted access with back ups* *Paper Records : Stores in files and cabinets with Restricted Access*	*Initiated by WQA officer and approved by RWQAM*	*Quality Assurance Officer*	*Archives*
SOPs/ Lab Quality Manual	*QA Officer*	*As and when procedures are reviewed*	*Electronic Records: Data management system with restricted access with back ups* *Paper Records : Stores in files and cabinets with Restricted Access*	*Initiated by WQA officer and approved by RWQAM.* *Reviewed when new equipment are procured and/or analytical methods reviewed*	*Quality Assurance Officer*	*Archives*
Sanitary Survey records of sampling sites	*Supervisor*	*Minimum of 2yrs*	*Paper Records : Stored in Files and cabinets*	*Initiated by WQA officer and approved by RWQAM*	*Quality Assurance Officer*	*Archives*
Proficiency Test records	*QA Officer*	*Life time of employee with organization*	*Electronic Records: Data management system with restricted access with back ups* *Paper Records : Stores in files and cabinets with Restricted Access*	*As and when new equipment are procured and/or analytical methods reviewed.* *Initiated by WQA officer and approved by RWQAM*	*Quality Assurance Officer*	*Archives*
Corrective Actions	*RWQAM*	*2 years*	*Electronic Records: Data management system with restricted access* *Paper Records : Stores in files and cabinets with Restricted Access*	*Initiated by RWQAM and Investigated by the QA Officer*	*Quality Assurance Officer*	*Archive*

8.0 Internal Quality System Audits

A laboratory audit ensures that the laboratory has quality systems in place, follows good laboratory practices, and generates data of integrity and quality.

It is strongly recommended that the Gahan Water Company Limited conducts its own internal quality audit for its laboratories with sufficient frequency to assure that test analyses provide continuously reliable results. An internal audit will also provide the laboratories with knowledge of how well it follows its own quality programme and prepare it for audients by clients.

Data generated by laboratories are used to make strategic decisions for all types of projects (investigation, remediation, compliance, etc.). It is important that the data are of the highest quality to avoid costly resampling and budget overruns. A laboratory audit ensures that the laboratory has quality systems in place, follows good laboratory practices, and generates data of integrity and quality.

The Quality Assurance Manager/Officer from the Head Office prepares a comprehensive annual audit programme, arranges for an internal quality system review and approved by the Chief Manager -Water Quality Assurance annually. The audit is carried out according to the Ghana Water Company Internal Laboratory Internal Audit SOP and by trained personnel who are independent (if possible) of the Laboratory being audited. The review process assesses the requirements of the quality assurance manual and SOPs against laboratory operations.

Two teams of internal Ghana Water Company Laboratory auditors are to be constituted (Northern and Southern sector teams respectively) led by a Quality Assurance Officer/Manager from the head office. The composition of the Audit teams should not include personnel from the laboratory being audited. Frequency for internal audit is once a year. In the situation where this requirement for annual audit is not meet, each laboratory would be required to do a thorough review of procedures annually and submit a report to Chief Manager- Water Quality Assurance

The results of the audits must be properly documented in writing and provided to the Chief Manager -WQA. Where audit findings are doubtful of the validity or correctness of the quality assurance manual against laboratory operations, and laboratory operations against the laboratory's quality assurance manual and SOPs, the laboratory will take immediate corrective actions within two months. Any corrective actions taken shall be properly documented.

The Chief Manager -WQA ensures that the corrective actions are taken within the agreed time frame. Any authority (e.g. Regional. Chief Manager and the Regional Water Quality Assurance Manager) in whose region an adverse finding is made during the audit process shall be duly notified in writing for remedial action to be taken.

8.1 Protocols for Performing a Laboratory Quality Audit

The success of the audit is based on adequate preparation, precise performance, well documented and insightful reporting, and productive follow-up.

1. **HOW TO PREPARE: Define the purpose of the audit.** Quality audits are performed to analyze the effectiveness and implementation of programs designed to maximize the quality of goods or services delivered to the customer. The scope and technical processes involved lead to determining the needed audit team resources.
2. **Define the scope of the audit.** The scope of the laboratory quality audit is defined as to limits or boundaries. Will the scope be corporate/organization-wide; the central/regional laboratory; or a system (Process) laboratory? Will all analytical methodologies or a specific subset be covered? What impact will the audit scope have on the laboratory personnel and operations?
3. **Determine the audit team resources to be used.** Determine what special skills/knowledge is needed among the team members to efficiently and effectively handle the scope of the audit.
4. **Identify the authority for the audit.** The authority for the audit comes from the Ghana Water Company Limited Quality Assurance Manual, the contract for the analytical services or the request for the third party audit.
5. **Identify the performance standards to be used.** The laboratory quality system has as many shapes, pieces and names for the pieces as there are authors. As a result, the audit team must evaluate the auditee's quality system against a standard. This does not mean that all laboratory quality systems are identical or should be. The challenge is to make sure that however the auditee's quality system is named and described; all the necessary functions are covered and implemented. The audit team will correlate the auditee's system against the auditor's system for equivalency of coverage.
6. **Develop a technical understanding of the processes to be audited.** The audit team will function more effectively and efficiently if it has a good understanding of the laboratory's quality system. The auditors required to **STUDY** Quality Manual and implementing procedures and historical information from prior audits (if available) prior to reaching the laboratory and this provides the mechanism to focus on the "mission critical" issues and develop better checklists.
7. **Contact those to be audited.** The auditee is informed of the audit by the mechanism appropriate for the situation. The Lead Auditor needs to make sure it is done or do it, as the situation dictates. This initial contact provides the opportunity to establish rapport with the auditee, to work out the logistics of the audit and to acquire documents necessary for preparation, if not already available. The formal audit plan is transmitted to the auditee upon its approval.
8. **Perform an initial evaluation of lower-tier documents to higher-level requirements.** This process is part of the education of the audit team. The process also provides much of the focus for the actual on-site data gathering efforts.

9. **Develop written checklists of the data needs.** The focus developed in the preceding section is documented in the development of the checklists. Where the audit program is used to cover multiple comparable laboratories, some parts of the checklists are generic. The main function of the checklist is to gather data, so the specific issues to be examined must be adequately listed. The audit question must also be directly linked to the standard that established the requirement. This technique provides protection from the checklist being an auditor's "wish list". The checklists must be reviewed or approved (generally by the Lead Auditor- the Quality Assurance Officer/Manager and approved by the Chief Manager -WQA) See attachment 18.

9.0 Management Review

Management of Ghana Water Company Limited reviews laboratory quality management systems and operations for all laboratories annually. This is to introduce continuous improvement in a coordinated manner by the head office in all GWCL laboratories in the regions.

The review process shall be initiated by the Water Quality Assurance Manager/Officer from the Head Office and approved by the Chief Manager – Water Quality Assurance. The process can also be initiated by the Regional Quality Assurance Managers and approved (Signed) by the Chief Manager – Water Quality Assurance.

The review takes into account the outcome of recent internal audits, inspections by external bodies (Third party auditors), Changes in SOPs and Laboratory Quality Manuals, Analytical Methods, results of inter-laboratory comparisons, results of proficiency tests, any changes in the volume and type of work undertaken, feedback from authorities, personnel or clients, and corrective actions. The findings and any corrective actions from this review must be properly documented.

10.0 Personnel Training

Before conducting any analysis, each analyst receives training by another analyst or supervisor who has completed training in the area. An analyst under training must be supervised by an experienced individual for all categories of staff. All training should mention that it is documented, and signed by a supervisor. The documentation should be placed in personnel file of the staff.

- For newly engaged staff for all categories of personnel must undergo a well-coordinated orientation programme for not less than three months. Areas of orientation should cover, Physico-Chemical analysis of water, Microbiology, Laboratory Quality Assurance/Control techniques, Best Laboratory practices, Water treatment Process control and Water treatment.

- Training needs for all categories of staff must be identified in collaboration with the HR and staff must be trained accordingly.

In-house /external training should be provided to every staff in the form of educational courses, professional seminars, and continuing proficiency testing. The training needs for the various categories of staff are outlined as follows:

10.1 Technicians (Water Quality Assurance)

Technician must upgrade themselves in the following areas:

1. A formal training in Science Laboratory Technology Certificate
2. Instrumentation operation, calibration and maintenance
3. Laboratory Quality Assurance/ Control techniques (Sampling, Analysis, Data generation)
4. Data Management and basic report writing skills
5. Best Laboratory Practices
6. Successful analysis of a Proficiency Test sample for each analysis that is regularly performed, once a year. This is required for staff who frequently runs a specific test or a staff being reassigned to a new set of tests or a new positions.

10.2 Supervisors (Water Quality Assurance)

Supervisor must upgrade themselves in the following areas:

1. A formal training in Higher National Diploma in Chemistry, Biochemistry, Science Laboratory Technology, Chemical engineering, Microbiology or relevant related field
2. Instrumentation
3. Laboratory Quality Assurance/ Control techniques
4. Data Management, statistical analysis and quality management systems

5. report writing Skills
6. Best Laboratory Practices
7. Practice of supervision

10.3 Water Quality Assurance Officers

WQA Officers must upgrade themselves in the following areas:

1. must upgrade in formal training in BSc/BTech in Chemistry, Biochemistry, Science Laboratory Technology, Chemical engineering, Environmental Science/Engineering, Microbiology or relevant related field
2. Total Quality Management
3. Instrumentation
4. Laboratory Quality Assurance/ Control techniques
5. Data Management, statistical analysis and quality management systems
6. Relevant ISO Quality management systems
7. Report writing skill
8. Best Laboratory Practices
9. Use of Water Quality Models and application of GIS Mapping

10.4 Regional Water Quality Assurance Managers

1. Must upgrade to a formal training in MSc in Chemistry, Biochemistry, Science Laboratory Technology, Chemical engineering, Environmental Science/Engineering, Microbiology or relevant related field
2. Total Quality Management
3. Instrumentation
4. Laboratory Quality Assurance/ Control Technique
5. Data Management, statistical analysis and quality management systems
6. Relevant ISO Quality management systems
7. Report writing skills
8. Best Laboratory Practices
9. Use of Water Quality Models/GIS Mapping

10.5 Chief Manager-Water Quality Assurance

Must upgrade him/herself in any area of weakness as outlined below:

1. MBA in a relevant field
2. Total Quality Management
3. Instrumentation

4. Laboratory Quality Assurance/Quality Control Technique
5. Data Management, statistical analysis and quality management systems
6. Relevant ISO Quality management systems
7. Report writing skills
8. Best Laboratory Practices
9. Use of Water Quality Models/GIS Mapping

In all cases, staff training and performance is considered complete after the analyst has produced a successful initial demonstration of method capability for the analysis for which he/she is responsible. In addition, acceptable results from a proficiency testing sample or internal blind quality control sample are documented for the analyst.

The Chief Manager Water in consultation with Chief Manager Human Resources and Administration Services identifies and approves all trainings for staff at the national levels. The Regional Water Quality Assurance Manager in consolation with Regional Human Resources Manager identify training needs for staff and approved by the Regional Chief Manager

All training sessions are documented and kept on file. At the end of each training sessions, the Quality Assurance Officer then conducts a Proficiency Test to assess the capabilities of the trained staff. After successful training and demonstration, the Regional WQA Manager and Officer sign the Demonstration of Capability Forms as certification of the analyst's performance.

11.0 Facilities and Environmental Conditions

All Ghana Water Company Limited laboratories must be designed to meet standard specifications and operated from a safe and friendly environment. All the Laboratories must be spacious enough, well lighted and adequately ventilated with good plumbing and drainage systems. Each laboratory facility must have different laboratory rooms for Chemistry, Microbiology, Physical and Major Instruments etc.

Performance of Analytical Testing takes place only within the specific laboratory. Testing may take place only outside the laboratory for parameters that require measurement on the field during sampling (e.g. pH, Electrical conductivity, temperature, Dissolved oxygen and residual chlorine).

Every standard Ghana Water Company Laboratory should have the following facilities;

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- Separate laboratory rooms for Chemistry, Microbiology, Physical and Major Instruments etc.
- Separate offices and changing rooms for employees
- The Microbiology Laboratory should have the following components (Media preparation room, Inoculation room, Washing and Sterilization room, Changing room, Fume chamber, UV radiation facility)
- Fume hoods (fume chamber)
- Spacious working benches.
- Bench tops must be impervious to water, and resistant to acids, alkalis, organic solvents and moderate heat.
- Bench tops must be white in colour and should be possibly made of Epoxy.
- Exit and emergency doors that swing in the direction of travel.
- Emergency eye wash/safety showers located close to the exit doors.
- Fire and gas detection alarms and Fire extinguishers at vantage points
- Hazards communication signage holders for displaying hazards symbols at vantage points in each laboratory room.
- Hands-free operated hand washing sinks located near the exit door of each room.
- Automatic self-closing entrance doors (allow access and egress to physically challenged persons). The doors should be wide and high enough to allow easy access with large equipment.

12.0 Test Methods and Validation

12.1 List of Analytical Tests, Parameters, Method Reference, Method Detection Limits (MDL), and Reporting Limits

The following table contains List of Analytical Tests, Parameters, Method Reference, Minimum Detection Limits (MDL), and Reporting Limits

Table 12.1: GWCL TEST METHODS AND VALIDATION

ANALYTICAL METHODS				
Analytical test	***Analytical Method***	***REFERENCE METHOD***	***METHOD DETECTION LIMIT***	***REPORTING LIMITS***
pH	*Ion Selective Electrode/ Colorimetric*	*SM 4500-H^+ B 23rd Ed*	*≤2*	*4.0 – 10.0 SU*
E. Conductivity	*Ion Selective Electrode*	*SM 2510 B 23rd Ed*	*1µS/cm*	*3µS/cm*
Total Suspended Solids	*Gravimetric*	*SM 2540 D23rd Ed*	*1.0 mg/L*	*3mg/L*
TDS	*Ion Selective Electrode*	*SM 2130 B 23rd Ed*	*1.00mg/L*	*3.00mg/L*
Colour	*Colorimetric*	*SM 2540 D 23rd Ed*	*1Hu*	*5Hu*
Turbidity	*Photometric/Colorimetric*		*0.1NTU*	*0.5NTU*
Total Iron	*Spectrophotometric*	*SM 3500-Fe B 23rd Ed*	*0.02mg/L*	*0.06mg/L*
Manganese	*Spectrophotometric*	*SM 3500-Mn B 23rd Ed*	*0.007mg/L*	*0.021mgL*
Copper	*Spectrophotometric*	*SM 3500 Cu B23rd Ed*	*0.04mg/L*	*0.12mgL*
Zinc	*Spectrophotometric*	*SM 3500-Zn A 23rd Ed*	*0.01mg/L*	*0.03mg/L*
Nitrate	*Spectrophotometric*	*SM 4500-NO_3 E 23rd Ed*	*0.01mg/L*	*0.03mg/L*
Nitrite	Spectrophotometric	*SM 4500-NO_2 B 23rd Ed*	*0.002mg/L*	*0.06mg/L*
Ammonia	*Spectrophotometric*	*SM 4500-NH_3 D 23rd Ed*	*0.02mg/L*	*0.06mg/L*
Phosphates	*Spectrophotometric*	*SM 4500-P E 23rd Ed*	*0.02mg/L*	*0.06mgL*
Fluoride	*Spectrophotometric*	*SM 4500 –F D 23rd Ed*	*0.02mg/L*	*0.06mg/L*
Sulphate	*Spectrophotometric*	*SM 4500 –SO_4 E3rd Ed*	*2.00mg/L*	*6.00mg/L*
Total Alkalinity	*Titrimetric*	*SM 2320 B 23rd Ed*	*1.0mg/L*	*3.00mg/L*
Total Hardness	*Gravimetric*	*SM 2340 C 23rd Ed*	*1.0mg/L*	*3.00mg/L*
Chloride	*Spectrophotometric Titrimetric*	*SM4500 –Cl^- B 23rd Ed*	*N/A*	*200mg/L*
Total Coliform	*Membrane Filter*	*SM 9218 B & 9221 B, 23rd Ed*	*1.0 cfu/100ml*	1cfu/100ml
E.coli	*Membrane Filter*	*SM 9218 B & 9221 B, 23rd Ed*	*1.0 cfu/100ml*	1cfu/100ml

12.2 Conducting Demonstration of Method Performance

Whenever any Ghana Water Company Laboratory intends to introduce or implement a new method, an initial demonstration of method performance in accordance with method specifications must be conducted. This includes the following guidelines as described in the Standard Methods, 19th Edition:

- Determination of Limit of Detection (LOD)
- Determination of Limit of Quantitation (LOQ)
- Evaluation of Precision, Accuracy and Bias

- Evaluation of Selectivity

Initial demonstration of method performance must be repeated each time significant changes are made to instrumentation, personnel, or the method. Initial demonstration of performance is amended and documented accordingly. The process for conducting method validation and/or initial demonstration of performance is included in the Laboratory SOPs and Laboratory Quality Manuals.

13.0 Equipment, Reagents, Supplies, and Reference

Materials

All equipment, reagents, supplies, and reference materials necessary for analyses are kept on hand for the specific analysis for which the Water Quality Assurance Department of Ghana Water Company Limited Laboratories performs.

For calibrations of analytical instrumentation, the laboratory uses standards that assure that measurements made by the laboratory are traceable to national standards of measurement, such as NIST traceable standards (when available) or certified reference materials (when available) or other standard solution/material prepared in the laboratory according to an established SOP. To achieve traceability of measurements, the laboratory maintains detailed records identifying the analyst(s) responsible for each step of the analytical processes, the origin of all consumables, standards, and reagents used, unique identification of analytical instruments used, calibration records for all equipment used, dates and times of analyses conducted, procedures used for preparing reagents and for analyzing samples, and unique identification of each sample analyzed. Calibration procedures are established for all applicable tests. Details of these procedures should be provided in the SOP for the analysis.

13.1 Laboratory Equipment

- All equipment is properly maintained. Procedures for maintenance of equipment are documented in SOPs and equipment manuals.

- Any defective equipment or part is removed from service and labeled until repaired. Equipment or parts are not put back in service until the laboratory demonstrates that it is functioning correctly.
- All routine and non-routine maintenance and repairs are documented in laboratory records. Calibration records are maintained for all measuring equipment. See laboratory bench sheets and logs.

- Laboratory Support Equipment. All laboratory support equipment is calibrated, or verified, or both, before being put into service, and on a continuing basis. The procedures for the calibration and verification of the laboratory support equipment will be provided in the SOPs and equipment manuals.

13.2 Reagents and supplies

- Glassware is properly cleaned and maintained as specified in the SOPs. Any cleaning or maintenance requirements specified in the approved test procedure are followed.

- Analytical reagent grade materials, if available, are used by the laboratory.

- The laboratory does not use prepared reagents, standards, or purchased chemicals outside the expiration date of the material.

- All stock and standard solution containers are labeled with name of reagents, preparation date, expiration date, concentration, and initials of analyst preparing the solution. For the preparation of reagents, standards, and rinsing glassware, the laboratory uses water of the purity and quality specified by the Standard Operating Procedure*, published method, or regulation.*

13.3 Reference materials

- To ensure accurate and precise measurements, the laboratory uses reference materials traceable to a national standard of measurement where commercially available, such as NIST, or are traceable to certified reference materials.
- The laboratory retains the Calibration Certificates of Reference Materials to demonstrate the traceability. Table 13.3 indicts the list of Laboratory Equipment and Reference materials used in the Central Laboratory, Accra (See Attachment 17 for List of Laboratory Equipment and Reference Materials for all the regions

13.3 Listing of Laboratory Equipment and Reference Materials (Central Laboratory)

Laboratory equipment and reference materials					
Name	*Brand*	*Model*	*Requirements*	*Date Purchased*	*Status*
Analytical weighing Balance	*METTLER TOLEDO*	*PB303-L*	*Scale reads at least to 0.001 g*	*2011*	*Satisfactory*
Standard reference weights			*ASTM Class 1 or NIST Class S. Not corroded.*	*2011*	*Satisfactory*
Autoclave	*SHANGHAI SHENAN INSTRUMENT*	*LDZX_50KBS*	*Capable of reaching and maintaining sterilization conditions (121oC and 0.1MPa).* *Reference Thermometer and pressures gauges* *Temperature range 105-134°C* Pressure Range -0.1-0.3MPa	*2014*	*Satisfactory*
pH meter	*HACH*	*HQ40d*	*Accurate to 0.1 pH units*	*2016*	*Satisfactory*
pH standard buffers	*HACH*	*SenSion 105*	*pH Buffer solutions :4.0, 7.0 and 10.0. Bottles labelled when received/open* *Discarded after expiration date.*	*2016*	*Satisfactory*
Spectrophotometer	*HACH*	*DR 6000*	*HACH Standards (depending on analysis)*	*2016*	*Satisfactory*
Dry Air Oven	*Gallenkamp*	*SRe2*	*Reference Thermometer* *Temperature range ; 30-200°C*	*2005*	*Not functioning*
Incubator	*Panasonic*	*MIR-154-PE*	*Reference Thermometer* *Temperature range -10-60°C*	*2016*	*Satisfactory*
Fridge	*LABCOLD*	*RLPR02042*	*Reference Thermometer* *Temperature range: 4-32°C. Station at well ventilated area and on flat surface*	*2014*	*Satisfactory*
Thermometer			*Appropriate scale for intended use.* *NIST traceable or calibrated according to SOP*	*2013*	*Satisfactory*
Turbidity Meter	*HANNAH*	*Hi98713*	*Calibration Standards Range: 0.00-9.99NTU 10.00-99.9NTU and 100.0-1000.0NTU*	*2013*	*Satisfactory*
Flocculator	*SIBATA*	*N/A*	*Speed range : 0-200 r. p.m.*	*2000*	*Satisfactory*
Conductivity Meter	*HACH*	*HQ40d*	*Calibration standard solution : KCl or NaCl (0.01N)*	*216*	*Satisfactory*
Atomic Emission Spectrophotometer	*Agilent Technologies*	*4200 MP-AES*	*Agilent Standards (depending on analysis)*	*2016*	*Satisfactory*
Membrane Filtration Set Up	*Millipore*	*-*	*All aseptic precaution measures must be strictly adhered to*	*2017*	*Satisfactory*

13.4 Calibrations and Maintenance Procedures and Frequency

Table 13.5: Calibrations and Maintenance Procedures and Frequency of equipment

CALIBRATION AND MAINTENANCE			
INSTRUMENT	***BEST PRACTICES***	***FREQUENCY***	***DOCUMENTATION***
Analytical weighing Balance	1. *Clean* 2. *Check calibration* 3. *Service contract*	1. *Before use* 2. *Daily* 3. *Annually*	*Logbook*
Autoclave	1. *Cleaning* 2. *Handle with care* 3. *Monitor maximum temperature reached with reference thermometer* 4. *Monitor pressures* 5. *Service* 6. *Sterility controls run*	1. *Each use* 2. *Each use* 3. *Each use* 4. *Each use* 5. *Annually* 6. *Each use*	*Logbook*
pH meter	1. *Cleaning* 2. *Calibrate with three standard buffers that bracket target pH(4.0, 7.0 and 10.0)* 3. *Record/calculate slope according to SOP* 4. *Maintain and store electrodes properly* 5.	1. *At least daily* 2. *Each use* 3. *Monthly* 4. *Regularly* 5. *Annually*	*Logbook*
DR 6000 Spectrophotometer	1. *Clean* 2. *Handle/Clean sample cells appropriately* 3. *Maintenance as per manual. Keep the surface of the instrument, the cell compartment and all accessories clean a calibration Service contract d dry at all times.* 4. *calibration as per manufacture instructions* 5.	1. *At least daily* 2. *Each use* 3. *At least daily* 4. *manufacture instructions* 5. *annually*	*Logbook*
Dry Air Oven	1. *Cleaning* 2. *Monitor temperature with reference thermometer* 3. *Service contract* 4. *Sterility controls run*	1. *Each use* 2. *Record twice daily* 3. *Annually* 4. *Each use*	*Logbook*
Incubator	1. *Cleaning* 2. *Monitor temperature* 3. *Check digital temperature display with reference thermometer* 4. *Avoid over-crowding*	1. *Daily as needed* 2. *Record Twice Daily* 3. *Annually* 4. *Each use.*	*Logbook*

CALIBRATION AND MAINTENANCE			
INSTRUMENT	***BEST PRACTICES***	***FREQUENCY***	***DOCUMENTATION***
	5. Must be Calibrated annually by an external body		
Fridge	***1. Cleaning*** ***2. Monitor temperature with reference thermometer*** ***3. Service programme***	***1. Weekly*** ***2. Daily*** ***3. Yearly***	*Logbook*
Turbidity Meter	***1. Cleaning*** ***2. Calibrate with standards*** ***3. Service contract***	***1. Daily*** ***2. Each use*** ***3. Annually***	*Logbook*
Flocculator	***1. Cleaning*** ***2. Service contract***	***1. Daily*** ***2. Annually***	*Logbook*
Conductivity Meter	***1. Cleaning*** ***2. Calibrate with two or three standard buffers that*** ***3. Record/calculate slope*** ***4. Maintain and store electrodes properly*** ***5. Service contract***	***1. Daily*** ***2. Each use*** ***3. Each calibration*** ***4. All times*** ***5. Annually***	*Logbook*
Thermometer	***1. Calibrated against NIST-traceable reference thermometer*** ***2. Discarded if off by more than 1oC compared to reference thermometer*** ***3. Correction factor listed on label*** ***4. Protected against accidental breakage*** ***5. Reference thermometer re-calibrated***	***1. Annually*** ***2. Annually*** ***3. Annually*** ***4. Each use*** ***5.. Every 5 years***	*Logbook and label on thermometer*

14.0 Samples

Each sample is uniquely identified from collection to disposal. All samples are identified on the outside of the sample bottle. Each sample is recorded in the sample log book.

14.1 Sample Identification

Unique Identification and labeling system of samples in an analytical laboratory for the performance of analysis is of paramount importance. The Water Quality Assurance Department of the Ghana Water company System of identification and labeling of samples follow the pattern below:

The laboratory ID code is placed on the sample container as a durable label, using permanent ink which is clearly legible. All sample information are logged into the sample log book with the following information.

- Type of sample
- Region
- System/District (Source)
- Sampling station
- Date (Year, Month, Day)
- Sample Number
- Sample collection Time
- Collectors names
- Analyst's name

For example; Type of sample/region/system or district (source)/date (Year-Month-Day)/ sample number will be recorded on the sampling form (See attachment 6).

However, the following information must appear (written in ink on the sample bottles).

- Type of sample
- Date (Year, Month, Day)
- Sample Number
- Type of Analysis
- Method Number

For example if the sample collected is Raw Water (RW) or Final Water (FW) taken on year 2017, March 30th, it will be identified as follows:

RW/170330/001 or FW/170330/001 respectively

Abbreviation for sample type for the coding are illustrated in the table below (See Table 14.1

Table 14.1: Types of samples and codes

No	Type/source of sample	Abbreviations for Sample types for Coding
1	Raw water	RW
2	Settled Water	SW
3	Filtered Water	FW
4	Treated Water	TW
5	Distributed Water	DW
6	Borehole Water	BhW
7	Effluent Water	EW
8	Hand Dug Well	HdW
9	Bagged Water	BgW
10	Bottled Water	BW

14.2 Sample Acceptance Policy

After sample collection and transportation to the Laboratory, the laboratory will verify the integrity of the sample by checking for the following:

- Leakage or breakage
- Sample collection logbooks correctly completed or filled(sample receipt)
- Correct sample identification
    - A unique sample number
    - Sample type
    - Name of collector
    - Date and Time of Collection
    - Place of Collection
    - Preservative used
- Appropriate use of sample labels (such as water resistant) and use of permanent ink.
- Use of appropriate sample containers, adequate volume, preservation, and holding time as required by specific test methods
- Temperature of samples requiring thermal preservation (checked and recorded at time of sampling).
- Chain of Custody Form describes the procedures to be followed using chain-of -custody protocols for samples received. **(See attachment 7)**

A chain of custody should state the following:

- Company or system name
- Name of the site or location
- Time and date of collection
- If sample is a composite or grab
- Analyses or tests to be performed
- Sampler(s) name and signature
- Chain of custody of samples before arriving in the lab
- Sample receiver's name and signature
- Time and date of receiving sample

When the sample received does not meet the acceptance requirements, the condition of the sample is documented and the sample is rejected and re-collected in accordance with the laboratory's written sample acceptance policy.
(See attachment 7)

14.3 Storage of Samples in the Laboratory

The laboratory will store samples, sub-samples, and/or other preparation products such as extracts or digestants according to the specified conditions in the approved methodology. All samples, sub-samples, etc. will be protected from all potential sources of contamination, deterioration, or damage.

14.4 Sample Disposal

The laboratory follows its waste management plan or chemical safety program for sample disposal appropriate for the samples handled and wastes generated. Wastewater samples are disposed in the laboratory drain. Any material determined to be hazardous for disposal in a sanitary sewer will be taken to a hazardous disposal site.

- Mode of waste disposal will depend on type of waste generated by the laboratory and accordance with EPA-Ghana regulations
- Disposal of any kind waste in the sink should not be encouraged. However, Certain wastes can be exempted (some acidic or basic samples– w/o hazardous substance)provided they that they are proper neutralized before discharge
- All microbiological culture/media, after incubation must sterilized properly, before disposal in sink or trash.

15.0 Assuring the Quality of Test Results

GWCL laboratories demonstrate the quality of analytical results through the implementation of a quality control plan.

15.1 Laboratory Quality Control Standards

The quality control samples run in the laboratory is outlined in the Laboratory Quality Manuals and their respective SOPs. The Following Table indicate the list of quality control samples run in the laboratories.

Table 15.1: Laboratory Quality Control Standards

Quality Control Standards		
Analytical test	*Quality Control Sample*	***REFERENCE METHOD***
pH	*pH Buffers (4, 7.0 9.0 and 10)*	*SM 4500-H^+ B 23rd Ed*
E. Conductivity	*KCl standard(0.010M)*	*SM 2510 B 23rd Ed*
Total Dissolved Solids	*KCl Standard(0.010M)*	*SM 2540 D23rd Ed*
Turbidity	*Turbidity Standards (0.1, 10, 100, 1000NTU)*	*SM 2130 B 23rd Ed*
Total Suspended Solids	*N/A*	*SM 2540 D 23rd Ed*
Total Iron	*Standard Iron Solution (1000mg/L)*	*SM 3500-Fe B 23rd Ed*
Manganese	*Standard Manganese Solution (1000mg/L)*	*SM 3500-Mn B 23rd Ed*
Copper	*Standard Copper Solution (1000mg/L)*	*SM 3500 Cu B23rd Ed*
Zinc	*Standard Zinc Solution (1000mg/L)*	*SM 3500-Zn A 23rd Ed*
Nitrate	*Standard Nitrate Solution (1000mg/L)*	*SM 4500-NO_3 E 23rd Ed*
Nitrite	*Standard Nitrite Solution (1000mg/L)*	*SM 4500-NO_2 B 23rd Ed*
Ammonia	*Standard Ammonia Solution (1000mg/L)*	*SM 4500-NH_3 D 23rd Ed*
Phosphates	*Standard Phosphate Solution (1000mg/L)*	*SM 4500-P E 23rd Ed*
Fluoride	*Standard Fluoride Solution (1000mg/L)*	*SM 4500 –F D 23rd Ed*
Sulphate	*Standard Sulphate Solution (1000mg/L)*	*SM 4500 –SO_4 E3rd Ed*
Total Alkalinity	Analytical Grade of Calcium Carbonate	*SM 2320 B 23rd Ed*
Total Hardness	Analytical Grade of Calcium Carbonate	*SM 2340 C 23rd Ed*
Chloride	*Standard Sulphate Solution (1000mg/L)*	*SM4500 –Cl^- B 23rd Ed*
E.coli	*Positive and Negative Cultured Plates/ Blanks / Sterility test*	*SM 9218 B & 9221 B, 23rd Ed*
Total Coliforms	*Positive and Negative Cultured Plates/ Blanks/ Sterility test*	*SM 9218 B & 9221 B, 23rd Ed*
Heterotrophic Bacteria	*Positive and Negative Cultured Plates/ Blanks/ Sterility test*	*SM 9218 A 23rd Ed*

15.2 Proficiency Testing (PT) Samples

The primary aim of proficiency testing or (inter-laboratory comparisons) is to provide a quality assurance tool for individual laboratories to enable them to compare their performance with similar laboratories to take any necessary remedial action to facilitate improvement.

Ghana Water Company laboratories obtain Proficiency Test samples from Ghana Standards Authority and SGS -Ghana. Proficiency Testing are to be performed once per year. The following parameters are to be included in the testing: pH, Colour, Turbidity, Total Suspended Solids, Electrical Conductivity, Total Dissolved Solids, Total Iron, Manganese, Copper Zinc, Nitrate, Nitrite, Ammonia, Phosphates, Fluoride, Sulphate, Total Hardness, Total Alkalinity, Total Coliforms, *E. coli* and Heterotrophic Bacteria. These parameters are listed in the Laboratory Analytical manual.

Proficiency Test studies are analyzed in the same manner as regular samples. The same test method procedures and the same internal Quality Control protocol are used when analyzing Proficiency Tests studies.

If it happens that the laboratory fails a Proficiency Test study, further investigation of the cause is to be conducted. If the problems are identified after the investigation, a corrective action plan is outlined on the corrective action form and actions are completed in a timely manner and properly documented.

15.3 Split Sampling (Duplicate)

The Ghana Water Company laboratories shall collect duplicate samples and submit the duplicate to an external subcontract laboratory (ies) for confirmation of analysis twice a year, to ensure the results reported are always accurate. The external subcontract laboratories include the Ghana Standard Authority (GSA), SGS and Water Research Institute (WRI) of CSIR. If some discrepancies or problems are identified, a corrective action plan is outlined on the corrective action form and actions are completed in a timely manner.

16.0 REPORTING THE RESULTS

All data generated by the Ghana Water Company Limited needs to be recorded properly following acceptable laid down producers. The format for reporting of results by the GWCL's laboratories are spelt out as follows.

16.1 Procedures to Ensure Reported Data are Free from Errors

16.1.1 Data Validation:

The analyst who performs the analysis shall verify all data before they are entered into the log books. The data review is to include the following items:

- Calibration of the instruments (Confirm the calibration criteria are met.)
- Quality control data. (Confirm QC meets the acceptance criteria.)
- Calculations. (Check for calculation errors.)
- Documentation. (Check worksheets, logbooks and printouts for accuracy and completeness.)

Before final reporting is done, the data is validated by the Water Quality Assurance Officer to ensure that all quality control measures were adhered to and that the reported data is free from transcription and calculation errors. If the Quality Assurance Officer is not available for the data review before reports are released, the Supervisor shall review the data generated by the analyst through the same process. The reviewed data together with worksheets, log books and chain of custody must be submitted to the Regional Water Quality Assurance Manager for certification or endorsement.

16.2 Procedures for Data Qualifiers

Ghana Water Company Laboratories will add Data qualifiers to all data not meeting collection, analytical, or internal QC acceptance criteria of the reports to the client.

16.3 Procedures for Reporting Analytical Results

The following are procedures required of Ghana Water Company laboratories before reports on results of analytical testing are carried out:

- The analyst carries out the analytical tests following the approved standard procedures and enters data on worksheet
- The supervisor reviews and carries out the necessary calculations and records data into log books
- The Quality Assurance Officer reviews, verifies and validates the data through the criteria outlined in section 16.1 to ensure quality control measures were adhered to. If no discrepancies are found, the QA Officer shall prepare the laboratory report
- The QA officer further submits the report to the Regional Water Quality Assurance Manager for certification and endorsement.

17.0 Glossary

"Acceptance criteria" means specified limits placed on characteristics of an item, process, or service defined in requirement documents.

"Accuracy" means the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations. Accuracy is an indicator of data quality.

"Aliquot" means a portion of a sample taken for analysis.

"Analyst" or "laboratory technician" means the designated individual who performs the "hands-on" analytical methods and associated techniques and who is the one responsible for applying required laboratory practices and other pertinent quality controls to meet the required level of quality.

"Analyte" means the substance or physical property to be determined in samples examined.

"Analytical method" means a technical procedure for providing analysis of a sample, which may not include the sample preparation method.

"Audit" means a systematic evaluation to determine the conformance to quantitative and qualitative specifications of some operational function or activity.

"Batch" means environmental samples that are prepared together or analyzed together or both with the same process and personnel, using the same lot or lots of reagents. "Analytical batch" means a batch composed of prepared environmental samples (extracts, digestates or concentrates) that are analyzed together as a group. An analytical batch can include prepared samples originating from various environmental matrices and can exceed 20 samples. "Preparation batch" means a batch composed of one to 20 environmental samples of the same matrix that meets the criteria in this definition for "batch" and with a maximum time between the start of processing of the first and last sample in the batch to be 24 hours.

"Blank" means a sample that has not been exposed to the analyzed sample stream in order to monitor contamination during sampling, transport, storage or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero baseline or background value and is sometimes used to adjust or correct routine analytical results. Blanks include the following types:

1. Field blank. A blank prepared in the field by filling a clean container with pure deionized water and appropriate preservative, if any, for the specific sampling activity being undertaken.

2. Method blank. A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for sample analyses.

"Calibration" means to determine, by measurement or comparison with a standard, the correct value of each scale reading on a meter, instrument or other device. The levels of the applied calibration standard should bracket the range of planned or expected sample measurements.

"Calibration curve" means the graphical relationship between the known values, such as concentrations, of a series of calibration standards and their instrument response.

"Calibration standard" means a substance or reference material used to calibrate an instrument.

"Certified reference material" means a reference material one or more of whose property values are certified by a technically valid procedure, accompanied by or traceable to a certificate or other documentation that is issued by a certifying body.

"Corrective action" means the action taken to eliminate the causes of an existing nonconformity, defect or other undesirable situation in order to prevent recurrence.

"Demonstration of capability" means the procedure to establish the ability of the analyst to generate data of acceptable accuracy and precision.

"Detection limit" means the lowest concentration or amount of the target analyte that can be determined to be different from zero by a single measurement at a stated degree of confidence.

"Document control" means the act of ensuring that documents, and revisions to the documents, are proposed, reviewed for accuracy, approved for release by authorized personnel, distributed properly and controlled to ensure use of the correct version at the location where the prescribed activity is performed.

"Environmental laboratory" or "laboratory" means a facility or a defined area within a facility where environmental analysis is performed. A structure built solely to shelter field personnel and equipment from inclement weather shall not be considered an environmental laboratory.

"Facility" means something that is built or installed to serve a particular function.

"Field testing and measurement" means any of the following:

1. Any test for parameters for which the holding time indicated for the sample requires immediate analysis

2. Examples of field tests or measures include tests for pH, residual chlorine and temperature.

"Finding" means an inspection conclusion that identifies a condition having a significant effect on an item or activity. An inspection finding is normally a deficiency and is normally accompanied by specific examples of the observed condition.

"Holding time (or maximum allowable holding time)" means the maximum time that a sample may be held prior to analysis and still be considered valid or not compromised.

"Internal standard" means a known amount of standard added to a test portion of a sample as a reference for evaluating and controlling the precision and bias of the applied analytical method.

"International System of Units (SI)" means the coherent system of units adopted and recommended by the General Conference on Weights and Measures.

"Laboratory control sample" or "LCS" means a sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is generally used to establish intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system. "Laboratory control sample" or "LCS" may also be named laboratory fortified blank, spiked blank, or QC check sample.

"Laboratory duplicate" means aliquots of a sample taken from the same container under laboratory conditions and processed and analyzed independently.

"Laboratory manager" means the person who has overall responsibility for the technical operation of the Water Utility laboratory and who exercises actual day-to-day supervision of laboratory operation for the appropriate fields of testing and reporting of results. The title of this person may include but is not limited to laboratory director, technical director, laboratory supervisor or laboratory manager.

"Legal entity" means an entity, other than a natural person, who has sufficient existence in legal contemplation that it can function legally, be sued or sue and make decisions through agents as in the case of corporations.

"Limit of detection" or "LOD" means an estimate of the minimum amount of a substance that an analytical process can reliably detect. An LOD is analyte and matrix specific and may be laboratory dependent.

"Limit of quantitation" or "LOQ" means the minimum levels, concentrations, or quantities of a target variable (e.g., target analyte) that can be reported with a specified degree of confidence.

"Matrix" means the component or substrate that may contain the analyte of interest.

"Matrix spike (spiked sample or fortified sample)" means a sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available. Matrix spikes are used, for example, to determine the effect of the matrix on a method's recovery efficiency.

"Matrix spike duplicate (spiked sample or fortified sample duplicate)" means a second replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte.

"Method detection limit" means one way to establish a limit of detection, defined as the minimum concentration of a substance (an analyte) that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte.

"National Institute of Standards and Technology" or "NIST" means an agency of the U.S. Department of Commerce's Technology Administration that is working with EPA, states, and other public and commercial entities to establish a system under which private sector companies and interested states can be certified by NIST to provide NIST-traceable proficiency testing (PT) samples.

"Negative control" means measures taken to ensure that a test, its components, or the environment do not cause undesired effects, or produce incorrect test results.

"Preservation" means refrigeration and/or reagents added at the time of sample collection, or later, to maintain the chemical and/or biological integrity of the sample.

"Physical," for the purposes of fee test categories, means the tests to determine the physical properties of a sample. Tests for solids, turbidity and color are examples of physical tests.

"Positive control" means measures taken to ensure that a test or its components are working properly and producing correct or expected results from positive test subjects.

"Precision" means the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. Precision is an indicator of data quality. Precision is expressed usually as standard deviation, variance or range, in either absolute or relative terms.

"Proficiency test or testing (PT)" means evaluating a laboratory's performance under controlled conditions relative to a given set of criteria through analysis of unknown samples provided by an external source.

"Proficiency test (PT) field of testing" means the approach to offer proficiency testing by matrix, technology/method, and analyte/analyte group.

"Proficiency test (PT) sample" means a sample, the composition of which is unknown to both the analyst and the laboratory provided to test whether the analyst or laboratory or both can produce analytical results within specified acceptance criteria.

"Proficiency testing (PT) program" means the aggregate of providing rigorously controlled and standardized environmental samples to a laboratory for analysis, reporting of results, statistical evaluation of the results and the collective demographics and results summary of all participating laboratories.

"Quality assurance" means an integrated system of activities involving planning, quality control, quality assessment, reporting and quality improvement to ensure that a product or service meets defined standards of quality with a stated level of confidence.

"Quality assurance officer" means the person who has responsibility for the quality system and its implementation. Where staffing is limited, the quality assurance officer may also be the laboratory manager.

"Quality control" means the overall system of technical activities whose purpose is to measure and control the quality of a product or service so that it meets the needs of users.

"Quality control sample" or "QC sample" means a sample used to assess the performance of all or a portion of the measurement system. QC samples may be certified reference materials, a quality system matrix fortified by spiking, or actual samples fortified by spiking.

"Quality manual" means a document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality of its product and the utility of its product to its users.

"Quality system" means a structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required quality assurance and quality control.

"Range" means the difference between the minimum and maximum of a set of values.

"Reference material" means a material or substance one or more properties of which are sufficiently well established to be used for the calibration of an apparatus, the assessment of a measurement test method, or for assigning values to materials.

"Reference standard" means a standard, generally of the highest metrological quality available at a given location, from which measurements made at that location are derived.

"Responsible official"

If the laboratory is owned or operated by a governmental body, "responsible official" means a director or highest official appointed or designated to oversee the operation and performance of the activities of the environmental laboratory.

Any person designated as the responsible official by the government body in this definition, provided the designation is in writing, the designation specifies an individual or position with responsibility for the overall operation of the environmental laboratory.

"Sample tracking" means procedures employed to record the possession of the samples from the time of sampling until analysis, reporting, and archiving. These procedures include the use a Chain of Custody Form that documents the collection, transport, and receipt of compliance samples to the laboratory. In addition, access to the laboratory is limited and controlled to protect the integrity of the samples.

"Sampling" means the act of collection for the purpose of analysis.

"Sewage" means the water-carried human wastes from residences, buildings, industrial establishments or other places together with such industrial wastes and underground, surface, storm, or other water as may be present.

"Spike" means a known mass of target analyte added to a blank sample or sub-sample, used to determine recovery efficiency or for other quality control purposes.

"Standard operating procedure (SOP)" means a written document that details the method of an operation, analysis or action whose techniques and procedures are thoroughly prescribed and which is accepted as the method for performing certain routine or repetitive tasks.

"Standardized reference material (SRM)" means a certified reference material produced by the U.S. National Institute of Standards and Technology or other equivalent organization and characterized for absolute content, independent of analytical method.

"Statistical Minimum Significant Difference (SMSD)" means the minimum difference between the control and a test concentration that is statistically significant; a measure of test sensitivity or power. The power of a test depends in part on the number of replicates per concentration, the significance level selected, e.g., 0.05, and the type of statistical analysis. If the variability remains constant, the sensitivity of the test increases as the number of replicates is increased.

"Test" means a technical operation that consists of the determination of one or more characteristics or performance of a given product, material, equipment, organism, physical phenomenon, process or service according to a specified procedure.

"Test method" means an adoption of a scientific technique for performing a specific measurement as documented in a laboratory standard operating procedure or as published by a recognized authority.

"Test sensitivity/Power" means the minimum significant difference (MSD) between the control and test concentration that is statistically significant. It is dependent on the number of replicates per concentration, the selected significance level, and the type of statistical analysis.

"Traceability" means the property of a result of a measurement whereby it can be related to appropriate standards, generally international or national standards, through an unbroken chain of comparisons.

"Validation" means the confirmation by examination and provision of objective evidence that the particular requirements of a specific intended use are fulfilled.

"Verification" means the confirmation by examination and provision of evidence that specified requirements have been met. NOTE: In connection with the management of measuring equipment, verification provides a means for checking that the deviations between values indicated by a measuring instrument and corresponding known values of a measured quantity are consistently smaller than the maximum allowable error defined in a standard, regulation or specification peculiar to the management of the measuring equipment. The result of verification leads to a decision either to restore in service, to perform adjustment, to repair, to downgrade, or to declare obsolete. In all cases, it is required that a written trace of the verification performed shall be kept on the measuring instrument's individual record.

"Waterworks" means each system of structures and appliances used in connection with the collection, storage, purification, and treatment of water for drinking or domestic use and the distribution thereof to the public, except distribution piping.

"Working range" means the difference between the limit of quantitation and the upper limit of measurement system calibration.

ATTACHMENTS

ATTACHMENT 1: APPROVAL SIGNATORIES (for Laboratory reports)

Regional Water Quality Assuarnce Manager [**Name]**

_____ _____ _____
Signature **Initials** **Date**

Water Quality Assurance Officer [Name]

_____ _____ _____
Signature **Initials** **Date**

ATTACHMENT 2: DOCUMENT CONTROL FORM

Name of Document	Date	Time	Name of officer assessing document		Approving office		Date returned	Signature
			Name	Signature	Name	Signature		

Remarks:

ATTACHMENT 3: COMPLAINTS FORMS

Details of Complainant					Nature of complaint	Action taken	Additional information	Person receiving complaint	Signature of Person receiving complaint	Date of giving feedback to complaint
Name	Date & Time	Address	Tel	Source of complaint						

Remarks:

ATTACHMENT 4: PRACTICAL TESTING FORM

Name of technician (trainee)
Function:
Date of Employment:

		Date of training			Initial of Lab Tech	Initials of trainer	Initials of QA manager
SOP No.	Test Method	Day 1	Day 2	Day 3			

Remarks:

ATTACHMENT 5: EMPLOYEE PROFICIENCY PERFORMANCE FORM

(Name of organization): Ghana Water Company Limited
Employee Laboratory Procedure Check List:
Employee _____
Supervisor (Observer) _____
Start Date _____

Test Method	Date	Employee signature	Observer signature	Marks Score	Pass/Fail

Remarks

ATTACHMENT 6: SAMPLE IDENTIFICATION FORM

Sample ID		Sample Code	
Sample Number		Date/Time of Sampling	
Region		System/District	
Sampling Station			
Type of Sample		Designate (Grab or Composite)	
Type of Analysis			
Type of Preservative			
Name of Sampler and Signature			

ATTACHMENT 8: SIGNATURE PAGE

(List as appropriate)

Water Quality Assurance Manager [Name]

_____ _____ _____
Signature **Initials** **Date**

Quality Assurance Officer [Name]

_____ _____ _____
Signature **Initials** **Date**

ATTACHMENT 9. EXAMPLE: DOCUMENT LISTING

(

Document Number	Document Name	Revision Number	Revision Number
SOP 001	Turbidity	N/A	
SOP 002	Total Suspended Solids	N/A	
SOP 003	pH	N/A	
SOP 004	*E. Coli*	N/A	
		N/A	
WS001	Turbidity Worksheet	N/A	
WS002	Total Suspended Solids Worksheet	N/A	
WS003	pH Work Sheet	N/A	
WS004	*E. Coli*	N/A	
		N/A	
TR001	Analyst Training Form	N/A	
TR002	Demonstration of Capability	N/A	
MR001	Management Review Format	N/A	
IA001	Internal Audit Form	N/A	
CA001	Corrective Action Form	N/A	

ATTACHMENT 10 A: TEST METHOD SOP FORMAT

HEADER

SOP # Effective Date:
Revision #:
Laboratory Manager Approval: _____ Date:_____

Quality Assurance Officer Approval: _____ Date: _____

Standard Operating Procedure (SOPs) for Hanna HI 93703 Turbidimeter for the determination of turbidity by FTU/ NTU.

METHOD 100.3
1.0 Operation of Hanna HI 93703 Ion electrode Turbidimeter for the determination of turbidity by FTU/ NTU.
2.0 APPLICATION MATRIX OR MATRICES

2.1 The method is suitable for the determination of turbidity in drinking, ground, surface, and saline, domestic and industrial wastes water.

3.0 METHOD DETECTION LIMIT
3.1
3.2 The applicable range is 0-40 Formalin turbidity units (FTU). Higher values may be obtained by dilution of the sample.

4.0 SCOPE OF THE TEST METHOD

4.1 This standard operating procedure provides Ghana Water Company Limited (GWCL) Laboratories personnel protocol for determining turbidity in water samples.

5.0 SUMMARY OF METHOD

5.1 The method is based upon a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension. The higher the intensity of scattered light, the higher the turbidity. Readings, in FTU's, are made in a formazin designed according to specifications given in Sections 6.1 and 6.2. A primary standard suspension is used to calibrate the instrument. A secondary standard suspension is used as a daily calibration check and is monitored periodically for deterioration using one of the primary standards.
5.1.1 Formazin polymer is used as a primary turbidity suspension for water because it is more reproducible than other types of standards previously used for turbidity analysis.
5.1.2 A commercially available polymer primary standard is also approved for use for the National Interim Primary Drinking Water Regulations. This standard is identified as AMCO-AEPA-1, available from Advanced Polymer Systems.

6.0 DEFINITIONS
6.1 Calibration Blank (CB) -- A volume of reagent water fortified with the same matrix as the calibration standards, but without the analytes, internal standards, or surrogates analytes.

6.1.1 Instrument Performance Check Solution (IPC) -- A solution of one or more method analytes, surrogates, internal standards, or other test substances used to evaluate the performance of the instrument system with respect to a defined set of criteria.
6.1.2 Laboratory Reagent Blank (LRB) -- An aliquot of reagent water or other blank matrices that are treated exactly as a sample including exposure to all glassware, equipment, solvents, reagents, internal standards, and surrogates that are used with other samples. The LRB is used to determine if method180.1-2analytes or other interferences are present in the laboratory environment, the agents, or the apparatus.
6.1.3 Linear Calibration Range (LCR) -- The concentration range over which the instrument response is linear.
6.1.4 Material Safety Data Sheet (MSDS) -- Written information provided by vendors concerning a chemical's toxicity, health hazards, physical properties, fire, and reactivity data including storage, spill, and handling precautions.
6.1.5 Primary Calibration Standard (PCAL) -- A suspension prepared from the primary dilution stock standard suspension. The PCAL suspensions are used to calibrate the instrument response with respect to analyte concentration.
6.1.6 Quality Control Sample (QCS) -- A solution of the method analyte of known concentrations that is used to fortify an aliquot of LRB matrix. The QCS is obtained from a source external to the laboratory, and is used to check laboratory performance.
6.1.7 Secondary Calibration Standards (SCAL) -- Commercially prepared, stabilized sealed liquid or gel turbidity standards calibrated against properly prepared and diluted formazin or styrene divinyl benzene polymers.
6.1.8 Stock Standard Suspension (SSS) -- A concentrated suspension containing the analyte prepared in the laboratory using assayed reference materials or purchased from a reputable commercial source. Stock standard suspension is used to prepare calibration suspensions and other needed suspensions.

7.0 INTERFERENCES

7.1 The presence of floating debris and coarse sediments which settle out rapidly will give low readings. Finely divided air bubbles can cause high readings.
7.1.2 The presence of true color, that is the color of water which is due to dissolved substances that absorb light, will cause turbidities to be low, although this effect is generally not significant with drinking waters.
7.1.3 Light absorbing materials such as activated carbon in significant concentrations can cause low readings.

8.0 SAFETY

8.1 The toxicity or carcinogenicity of each reagent used in this method has not been fully established. Each chemical should be regarded as a potential health hazard and exposure should be as low as reasonably achievable.
8.1.2 Each laboratory is responsible for maintaining a current awareness file of OSHA regulations rth is method. A reference file of Material Safety Data Sheets (MSDS) should be made available to all personnel involved in the chemical analysis. The preparation of a formal safety plan is also advisable.
8.1.3 Hydrazine Sulfate (Section 10.2.1) is a carcinogen. It is highly toxic and may be lather if inhaled, swallowed, or absorbed through the skin. Formazin can contain residual hydrazine sulfate. Proper protection should be employed.

9.0 EQUIPMENT AND SUPPLIES

9.1 The turbidimeter shall consist of a nephelometer, with light source for illuminating the sample, and one or more photo-electric detectors with a read out device to indicate the intensity of light scattered at right angles to

the path of the incident light. The turbidimeter should be designed so that little stray light reaches the detector in the absence of turbidity and should be free from significant drift after a short warm-up period.
9.2 Differences in physical design of turbidimeters will cause differences in measured values for turbidity, even though the same suspension is used for calibration. To minimize such differences, the following design criteria should be observed:
9.2.1 Light source: Tungsten lamp operated at a color temperature between2200-3000°K.
9.2.2 Distance traversed by incident light and scattered light within the sample tube: Total not to exceed 10 cm.
9.2.3 Detector: Centered at 90° to the incident light path and not to exceed ±30° from 90°. The detector, and filter system if used, shall have a spectral peak response between 400 nm and 600 nm.
9.3 The sensitivity of the instrument should permit detection of a turbidity difference of 0.02 NTU or less in waters having turbidities less than 1 unit. The instrument should measure from 0-40 units turbidity. Several ranges may be necessary to obtain both adequate coverage and sufficient sensitivity for low turbidities.
9.3.1 The sample tubes to be used with the available instrument must be of clear, colorless glass or plastic. They should be kept scrupulously clean, both inside and out, and discarded when they become scratched or etched. A light coating of silicon oil may be used to mask minor imperfections in glass tubes. They must not be handled at all where the light strikes them, but should be provided with sufficient extra length, or with a protective case, so that they may be
Handled. Tubes should be checked, indexed and read at the orientation that produces the lowest background blank value.

9.3.2 Balance -- Analytical, capable of accurately weighing to the nearest 0.0001gm regarding the safe handling of the chemicals specified in6.6 Glassware -- Class A volumetric flasks and pipets as required.

10.0 REAGENTS AND STANDARDS

10.1 Reagent water, turbidity-free: Pass deionized distilled water through a 0.45µpore size membrane filter, if such filtered water shows a lower turbidity than unfiltered distilled water.
10.2 Stock standard suspension (Formazin):
10.2.1 Dissolve 1.00 g hydrazine sulfate, (NH2)2.H2SO4, (CASRN 10034-93-2) in reagent water and dilute to 100 mL in a volumetric flask. CAUTION--carcinogen.

10.2.2 Dissolve 10.00 g hexamethylenetetramine (CASRN 100-97-0) in reagent water and dilute to 100 mL in a volumetric flask. In a 100ml volumetric flask, mix 5.0 mL of each solution (Sections 7.2.1 and 7.2.2).Allow to stand 24 hours at 25 ±3°C, then dilute to the mark with reagent water.
10.3 Primary calibration standards: Mix and dilute 10.00 mL of stock standard suspension (Section 7.2) to 100 mL with reagent water. The turbidity of this suspension is defined as 40 NTU. For other values, mix and dilute portions of this suspension as required.
10.3.1 A new stock standard suspension (Section 7.2) should be prepared each month. Primary calibration standards (Section 7.3) should be prepared daily by dilution of the stock standard suspension.
10.4 Formazin in commercially prepared primary concentrated stock standard suspension (SSS) may be diluted and used as required. Dilute turbidity standards should be prepared daily.
10.4.1 AMCO-AEPA-1 Styrene Divinyl benzene polymer primary standards are available for specific instruments and require no preparation or dilution prior to use.
10.5 Secondary standards may be acceptable as a daily calibration check, but must be monitored on a routine basis for deterioration and replaced as required.

11.0 SAMPLE COLLECTION, PRESERVATION AND STORAGE

11.1 Samples should be collected in plastic or glass bottles. All bottles must be thoroughly cleaned and rinsed with turbidity free water. Volume collected should be sufficient to insure a representative sample, allow for replicate analysis (if required), and minimize waste disposal.
11.2 No chemical preservation i8.3 Samples should be analyzed as soon as possible after collection. If storage is required, samples maintained at 4°C may be held for up to 48 hours.

12.0 QUALITY CONTROL

12.1 Each laboratory using this method is required to operate a formal quality control (QC) program. The minimum requirements of this program consist of an initial demonstration of laboratory capability and analysis of laboratory reagent blanks and other solutions as a continuing check on performance. The Laboratory is required to maintain performance records that define the quality of data generated.

12.2 INITIAL DEMONSTRATION OF PERFORMANCE.

12..2.1 The initial demonstration of performance is used to characterize instrument performance (determination of LCRs and analysis of QCS).
12..2.2 Linear Calibration Range (LCR) -- The LCR must be determined initially and verified every six months or whenever a significant change in instrument response is observed or expected. The initial demonstration of linearity must use sufficient standards to insure that the resulting curve is linear. The verification of linearity must use a minimum of a blank and three standards. If any verification data exceeds the initial values by ±10%, linearity must be reestablished. If any portion of the range is shown to be nonlinear, sufficient standards must be used to clearly define the nonlinear portion.
12.2.3 Quality Control Sample (QCS) -- When beginning the use of this method, on a quarterly basis or as required to meet data-quality needs, verify the calibration standards and acceptable instrument performance with the preparation and analysis of a QCS. If the determined concentrations are not within ±10% of the stated values, performance of the determinative step of the method is unacceptable. The source of the problem must be identified and corrected before continuing with on-going analyses.

13.0 ASSESSING LABORATORY PERFORMANCE

13.1 Laboratory Reagent Blank (LRB) -- The laboratory must analyze at least one LRB with each batch of samples. Data produced are used to assess contamination from the laboratory environment.
13..2 Instrument Performance Check Solution (IPC) -- For all determinations, the laboratory must analyze the IPC (a mid-range check standard) and a calibration blank immediately following daily calibration, after every tenth sample (or more frequently, if required) and at the end of the sample run. Analysis of the IPC solution and calibration blank immediately follow within ±10% of calibration. Subsequent analyses of the IPC solution must verify the calibration is still within ±10%. If the calibration cannot be verified within the specified limits, reanalyze the IPC solution. If the second analysis of the IPC solution confirms calibration to be outside the limits, sample analysis must be discontinued, the cause determined and/or in the case of drift the instrument recalibrated. All samples following the last acceptable IPC solution must be reanalyzed. The analysis data of the calibration blank and IPC solution must be kept on file with the sample analyses data. NOTE: Secondary calibration standards (SS) may also be used as the IPC.
13.2.1 Where additional reference materials such as Performance Evaluation samples are available, they should be analyzed to provide additional performance data. The analysis of reference samples is a valuable tool for

demonstrating the ability to perform the method acceptably.

14.0 CALIBRATION AND STANDARDIZATION

14.1 Turbidimeter calibration: The manufacturer's operating instructions should be followed. Measure all standards on the turbidimeter covering the range of interest. If the instrument is already calibrated in standard turbidity units, this procedure will check the accuracy of the calibration scales. At least one standard should be run in each instrument range to be used. Some instruments permit adjustments of sensitivity so that scale values will correspond to turbidities. Solid standards, such as those made of Lucite blocks, should never be used due to potential calibration changes caused by surface scratches. If a pre-calibrated scale is not supplied, calibration curves should be prepared for each range of the instrument.

15.0 PROCEDURE

15.1 Allow samples to come to room temperature before analysis. Mix the sample to thoroughly disperse the solids. Wait until air bubbles disappear then pour 10/15ml of the sample into the cell. Zero the instrument with distil water blank. Replace the blank with the sample and read the turbidity directly from the instrument readout displaced.
15.2 Turbidity exceeding 40 units: Dilute the sample with one or more volumes of turbidity-free water until the turbidity falls below 40 units. The turbidity of the original sample is then computed from the turbidity of the diluted sample and the dilution factor. For example, if 5 volumes of turbidity-free water were added to 1 volume of sample, and the diluted sample showed a turbidity of 30units, then the turbidity of the original sample was 180 units.
15.2.1 Some turbidimeters are equipped with several separate scales. The higher scales are to be used only as indicators of required dilution volumes to reduce readings to less than 40 NTU.ng calibrations must verify that the instrument is required. Cool sample to 4°C .Note: Comparative work performed in the Environmental Monitoring Systems Laboratory.

16.0 DATA ANALYSIS AND CALCULATIONS

16.1 Multiply sample readings by appropriate dilution to obtain final reading.
16.2 Report results as follows:
NTU/FTU Record to Nearest:
0.0 - 1.0, 0.05
1 – 10, 0.1
10 - 40, 1
40 – 100, 5
100 - 400, 10
400 – 1000, 50
>1000- 100

17.0 METHOD PERFORMANCE

17.1 In a single laboratory (EMSL-Cincinnati), using surface water samples at levels of 26, 41, 75, and 180 NTU, the standard deviations were ±0.60, ±0.94, ±1.2, and ±4.7 units, respectively.
17.2 The inter laboratory precision and accuracy data in Table 1 were developed using a reagent water matrix.

Values are in NTU.

18.0 POLLUTION PREVENTION

14.1 Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. The EPA has established a preferred hierarchy of environmental management techniques that places pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution prevention techniques to address their waste generation. When wastes cannot be feasibly reduced at the source, the Agency recommends recycling as the next best option.
14.2 The quantity of chemicals purchased should be based on expected usage during its shelf life and disposal cost of unused material. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.
14.3 For information about pollution prevention that may be applicable to laboratories and research institutions consult "Less is Better: Laboratory Chemical Management for WA Chemical Society's Department of Government Regulations and Science Policy,1155 16th Street N.W., Washington D.C. 20036, (202)872-4477.

19.0 WASTE MANAGEMENT

15.1 Ghana Water Company Limited requires that laboratory waste management practices be conducted consistent with all applicable rules and regulations. Excess reagents, samples and method process wastes should be characterized and disposed of in an acceptable manner. The Agency urges laboratories to protect the air, water and land by minimizing and controlling all releases from hoods, and bench operations, complying with the letter and spirit of any waste discharge permit and regulations, and by complying with all solid and hazardous waste regulations, particularly the hazardous waste identification rules and land disposal restrictions. For further information on waste management consult the "Waste Management Manual for Laboratory Personnel," available from the American Chemical Society at the address listed in Section 14.3.

20.0 REFERENCES

1. Annual Book of ASTM Standards, Volume 11.01 Water (1), Standard D1889-
88A, p. 359, (1993).
3. Standard Methods for the Examination of Water and Wastewater, 23rd Edition,

ATTACHMENT 10 B: TEST METHOD SOP FORMAT

HEADER

SOP # Effective Date:
Revision #:
Laboratory Manager Approval: _____ Date:_____
Quality Assurance Officer Approval: _____ Date: _____

STANDARD OPERATING PROCEDURE (SOPS) FOR TOTAL COLIFORMS AND ESCHERICHIA COLI ENUMERATION IN WATER BY MEMBRANE FILTRATION

Method 125.1

Total Coliforms and Escherichia coli enumeration in Water by Membrane Filtration)

1.0 SCOPE AND APPLICATION

1.1 This test method describes a sensitive and differential membrane filter (MF) medium, using I agar (Brilliance) or for the simultaneous detection and enumeration of both total coliforms (TC) and Escherichia coli (E. coli) in water samples in 24 hours on the basis of their specific enzyme activities. Two enzyme substrates, the fluorogen 4-Methylumbelliferyl-$-D-galactopyranoside (MUGal) and a chromogen Indoxyl-$-D-glucuronide (IBDG), are included in the medium to detect the enzymes $-galactosidase and $-glucuronidase, respectively, produced by TC and E. coli, respectively.
1.2 Total coliforms include species that may inhabit the intestines of warm-blooded animals or occur naturally in soil, vegetation, and water. They are usually found in fecally-polluted water and are often associated with disease outbreaks. Although they are not usually pathogenic themselves, their presence in drinking water indicates the possible presence of pathogens. E. coli, one species of the coliform group, is always found in feces and is, therefore, a more direct indicator of fecal contamination and the possible presence of enteric pathogens. In addition, some strains of E. coli are pathogenic (Reference 16.12).
1.3 This method, which has been validated for use with drinking water in single-lab and multi-lab studies (References 16.8 - 16.10), will be used primarily by certified drinking water laboratories for microbial analysis of potable water. Other uses include recreational, surface or marine water, bottled water, groundwater, well water, treatment plant effluents, water from drinking water distribution lines, drinking water source water, and possibly foods, pharmaceuticals, clinical specimens (human or veterinary), other environmental samples (e.g., aerosols, soil, runoff, or sludge) and/or isolation and separation of transformants though the use of E. coli lac Z or gus A/uid reporter genes (Reference 16.11).
1.4 Since a wide range of sample volumes or dilutions can be analyzed by the MF technique, a wide range of E. coli and TC levels in water can be detected and enumerated.

2.0 Summary of Method

2.1 An appropriate volume of a water sample (100 mL for drinking water) is filtered through a 47-mm, 0.45-µm pore size cellulose ester membrane filter that retains the bacteria present in the sample. The

filter is placed on a 5-mL plate of MI agar or on an absorbent pad saturated with 2-3 mL of MI broth, and the plate is incubated at 35°C for up to 24 hours. The bacterial colonies that grow on the plate are inspected for the presence of blue color from the breakdown of IBDG by the E. coli enzyme $-glucuronidase and fluorescence under longwave ultraviolet light (366 nm) from the breakdown of MUGal by the TC enzyme $-galactosidase (Reference 16.8).

3.0 Definitions

3.1 Total coliforms (TC) - In this method, TC are those bacteria that produce fluorescent colonies upon exposure to long wave ultraviolet light (366 nm) after primary culturing on MI agar or broth (See Figure 1.). The fluorescent colonies can be completely blue-white (TC other than E. coli) or blue-green (E. coli) in color or fluorescent halos may be observed around the edges of the blue-green E. coli colonies. In addition, non-fluorescent blue colonies, which rarely occur, are added to the total count because the fluorescence is masked by the blue color from the breakdown of IBDG (Reference 16.8).
3.2 Escherichia coli - In this method, the E. coli are those bacteria that produce blue colonies under ambient light after primary culturing on MI agar or broth (See Figures 1 and 2.). These colonies can be fluorescent or non-fluorescent under long wave ultraviolet light (366 nm) (Reference 16.8).

4.0 Interferences and Contamination

4.1 Water samples containing colloidal or suspended particulate material can clog the membrane filter, thereby preventing filtration, or cause spreading of bacterial colonies which could interfere with identification of target colonies. However, the blue E. coli colonies can often be counted on plates with heavy particulates or high concentrations of total bacteria (See Figures 2 and 3.) (Reference 16.8).
4.2 The presence of some lateral diffusion of blue color away from the target E. coli colonies can affect enumeration and colony picking on plates with high concentrations of E. coli. This problem should not affect filters with low counts, such as those obtained with drinking water or properly diluted samples (Reference 16.8).
4.3 Tiny, flat or peaked pinpoint blue colonies (# 0.5-mm in diameter on filters containing # 200 colonies) may be due to species other than E. coli. These colonies occur occasionally in low numbers and should be excluded from the count of the E. coli colonies, which are usually much larger in size (1-3-mm in diameter). The small colonies have never been observed in the absence of typical E. coli, but, if such should occur, the sample should not be considered E. coli-positive unless at least one colony has been verified by another method [e.g., EC medium with 4-Methylumbelliferyl-$-D-glucuronide (MUG) or API 20E strips] (Reference 16.8).
4.4 Bright green, fluorescent, non-blue colonies, observed along with the typical blue/white or blue-green fluorescent TC colonies, may be species other than coliforms. These colonies, which generally occur in low numbers (# 5%) and can usually be distinguished from the TC, should be eliminated from the TC count. An increase in the number of bright green colonies may indicate an unusual sample population or a breakdown of the cefsulodin in the medium (Reference 16.8).

5.0 Safety

5.1 The analyst/technician must know and observe the normal safety procedures required in a microbiology laboratory while preparing, using, and disposing of cultures, reagents, and materials, and while operating sterilization equipment.
5.2 Mouth-pipetting is prohibited.
5.3 Avoid prolonged exposure to long wave or germicidal ultraviolet light.

5.4 Autoclave all contaminated plates and materials at the end of the analysis from the American.

6.0 Equipment and Supplies

6.1 Incubator set at 37°C ± 0.5°C, with approximately 90% humidity if loose-lidded petri dishes are used.
6.2 Stereoscopic microscope, with magnification of 10-15x, wide-field type.
6.3 A microscope lamp producing diffuse light from cool, white fluorescent lamps adjusted to give maximum color.
6.4 Hand tally.
6.5 Pipet container of stainless steel, aluminum, or Pyrex glass, for pipets.
6.6 Graduated cylinders (100-mL for drinking water), covered with aluminum foil or kraft paper and sterilized.
6.7 Membrane filtration units (filter base and funnel), glass, plastic or stainless steel. These are
Wrapped with aluminum foil or kraft paper and sterilized.
6.8 Germicidal ultraviolet (254 nm) light box for sanitizing the filter funnels is desirable, but optional.
6.9 Line vacuum, electric vacuum pump, or aspirator is used as a vacuum source. In an emergency, a hand pump or a syringe can be used. Such vacuum-producing devices should be equipped with a check valve to prevent the return flow of air.
6.10 Vacuum filter flask, usually 1 liter, with appropriate tubing. Filter manifolds to hold a number of filter bases are desirable, but optional.
6.11 Safety trap flask, placed between the filter flask and the vacuum source.
6.12 Forceps, straight (preferred) or curved, with smooth tips to permit easy handling of filters without damage.
6.13 Alcohol, 95% ethanol, in small wide-mouthed vials, for sterilizing forceps.
6.14 Bunsen or Fisher-type burner or electric incinerator unit.
6.15 Sterile T.D. (To Deliver) bacteriological or Mohr pipets, glass or plastic (1-mL and 10-mL
Volumes).
6.16 Membrane Filters (MF), white, grid-marked, cellulose ester, 47-mm diameter, 0.45 µm ± 0.02-µm pore size, pre sterile or sterilized for 10 minutes at 121°C (15-lb pressure).
6.17 Long wave ultraviolet lamp (366 nm), handheld 4-watt (preferred) or 6-watt, or microscope
attachment.
6.18 Dilution water: Sterile phosphate-buffered dilution water, prepared in large volumes (e.g., 1 liter)for wetting membranes before addition of the sample and for rinsing the funnel after sample filtration or in 99-mL dilution blanks [Section 9050C in Standard Methods (Reference 16.2)].
6.19 Indelible ink marker for labeling plates.
6.20 Thermometer, checked against a National Institute of Science and Technology (NIST)-certified thermometer, or one traceable to an NIST thermometer.
6.21 Petri dishes, sterile, plastic, 9 x 50 mm, with tight-fitting lids, or 15 x 60 mm, glass or plastic, with loose-fitting lids; 15 x 100 mm dishes may also be used.
6.22 Bottles, milk dilution, borosilicate glass, screw-cap with neoprene liners, marked at 99 mL for 1:100 dilutions (if needed). Dilution bottles marked at 90 mL, or tubes marked at 9 mL may be used for 1:10 dilutions.
6.23 Flasks, borosilicate glass, screw-cap, 250- to 2000-mL volume, for agar preparation.
6.24 Water bath maintained at 50°C for tempering agar.
6.25 Syringe filter, sterile, disposable, 25-mm diameter, and 0.22-µm pore size, to filter cefsulodin for MI agar.
6.26 Syringe, sterile, plastic, disposable, 20-cc capacity. Autoclaved glass syringes are also acceptable.
6.27 Test tubes, sterile, screw-cap, 20 x 150-mm, borosilicate glass or plastic, with lids.
6.28 Sterilization filter units, pre sterile, disposable, 500- or 1000-mL capacity, and 0.2-µm pore size, to filter stock buffer solutions.

6.29 Sterile 47-mm diameter absorbent pads (used with MI broth).
Note: Brand names, suppliers, and part numbers are for illustrative purposes only. No endorsement is implied. Equivalent performance may be achieved using apparatus and materials other than those specified here, but demonstration of equivalent performance that meets the requirements of this method is the responsibility of the laboratory.

7.0 Reagents and Standards

7.1 Purity of Reagents: Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society (Reference 16.1). The agar used in preparation of culture media must be of microbiological grade.
7.2 Whenever possible, use commercial culture media as a means of quality control.
7.3 Purity of Water: Reagent-grade distilled water conforming to Specification D1193, Type II water or better, ASTM Annual Book of Standards (Reference 16.3).
7.4 Buffered Dilution Water (Reference 16.2)
7.4.1 Stock Phosphate Buffer Solution (Reference 16.2): Potassium Dihydrogen Phosphate (KH2PO4) 34.0 g Reagent-Grade Distilled Water 500 mL
7.4.2 Preparation of Stock Buffer Solution: Adjust the pH of the solution to 7.2 with 1 N NaOH, and bring volume to 1000 mL with reagent-grade distilled water. Sterilize by filtration or autoclave for 15 minutes at 121°C (15-lb pressure).
7.4.3 MgCl2 Solution (Reference 16.2): Dissolve 38 g anhydrous MgCl2 (or 81.1 g MgCl2C6H2O) in one liter of reagent-grade distilled water. Sterilize by filtration or autoclave for 15 minutes at 121°C (15-lb pressure).
7.4.4 Storage of Stock Buffer and MgCl2 Solutions: After sterilization of the stock solutions, store in the refrigerator until used. Handle aseptically. If evidence of mold or other contamination appears in either stock, the solution should be discarded, and a fresh solution should be prepared.
7.4.5 Working Solution (Final pH 7.0 ± 0.2): Add 1.25 mL phosphate buffer stock (Section 7.4.2) and 5 mL MgCl2 stock (Section 7.4.3) for each liter of reagent-grade distilled water prepared. Mix well, and dispense in appropriate amounts for dilutions in screw-cap dilution bottles or culture tubes, and/or into larger containers for use as rinse water. Autoclave at 121°C (15-lb pressure) for 15 minutes. Longer sterilization times may be needed depending on the container and load size and the amount of time needed for the liquid to reach 121°C.
7.5 MI Agar (Reference 16.8)
7.5.1 Composition: Protease Peptone #35.0 g Yeast Extract 3.0 g $-D-Lactose1.0 g 4-Methylumbelliferyl-$-D-Galactopyranoside (MUGal)(Final concentration 100µg/mL) 0.1 g Indoxyl-$-D-Glucuronide (IBDG) (Final concentration 320 µg/mL) 0.32 g NaCl 7.5 g K2HPO4 3.3 g KH2PO4 1.0 g Sodium Lauryl Sulfate 0.2 g Sodium Desoxycholate 0.1 g Agar 15.0 g Reagent-Grade Distilled Water 1000 mL
7.5.2 Cefsulodin Solution (1 mg / 1 mL): Add 0.02 g of cefsulodin to 20 mL reagent-grade distilled water, sterilize using a 0.22-µm syringe filter, and store in a sterile tube at 4°C until needed. Prepare fresh solution each time. Do not save the unused portion.
7.5.3 Preparation: Autoclave the medium for 15 minutes at 121°C (15-lb pressure), and add 5 mL of the freshly-prepared solution of Cefsulodin (5 µg/mL final concentration) per liter of tempered agar medium. Pipet the medium into 9 x 50-mm Petri dishes (5 mL/plate). Store plates at 4°C for up to 2 weeks. The final pH should be 6.95 ± 0.2.
7.6 MI Broth: The composition of MI broth is the same as MI agar, but without the agar. The final pH of MI broth should be 7.05 ± 0.2. The broth is prepared and sterilized by the same methods described for MI agar in Sections 7.5.1, 7.5.2, and 7.5.3, except that absorbent pads are placed in 9 x 50 mm Petri dishes and saturated with 2-3 mL of MI broth containing 5 :g/mL final concentration of Cefsulodin. Alternately, the broth can be filter-sterilized.

Excess broth is poured off before using the plates. Plates should be stored in the refrigerator and discarded after 96 hours (Reference 16.15).

7.7 Tryptic Soy Agar/Trypticase Soy Agar (Difco 0369-17-6, BD 4311043, Oxoid CM 0129B, or equivalent) (TSA)

7.7.1 Composition:Tryptone 15.0 g Soytone 5.0 g NaCl 5.0 g Agar 15.0 g

7.7.2 Preparation: Add the dry ingredients listed above to 1000 mL of reagent-grade distilled water, and heat to boiling to dissolve the agar completely. Autoclave at 121°C (15-lb pressure) for 15 minutes. Dispense the agar into 9 x 50-mm petri dishes (5 mL/plate). Incubate the plates for 24 - 48 hours at 35°C to check for contamination. Discard any plates with growth. If > 5% of the plates show contamination, discard all plates, and make new medium. Store at 4°C until needed. The final pH should be 7.3 ± 0.2.

8.0 Sample Collection, Preservation, and Storage

8.1 Water samples are collected in sterile polypropylene sample containers with leak-proof lids.

8.2 Sampling procedures are described in detail in Sections 9060A and 9060B of the 18th edition of Standard Methods for the Examination of Water and Wastewater (Reference 16.2) or in the USEPA Microbiology Methods Manual, Section II, A (Reference 16.6). Residual chlorine in drinking water (or chlorinated effluent) samples should be neutralized with sodium thiosulfate (few cystals) at the time of collection. Adherence to sample preservation procedures and holding time limits are critical to the production of valid data. Samples not collected according to these rules should not be analyzed.

8.2.1 Storage Temperature and Handling Conditions: Ice or refrigerate water samples at a temperature of 1-4°C during transit to the laboratory. Use insulated containers to assure proper maintenance of storage temperature. Take care that sample bottles are not totally immersed in water from melted ice during transit or storage.

8.2.2 Holding Time Limitations: Analyze samples as soon as possible after collection. Drinking water samples should be analyzed within 30 h of collection (Reference 16.13). Do not hold source water samples longer than 6 h between collection and initiation of analyses, and the analyses should be complete within 8 h of sample collection.

9.0 Calibration and Standardization

9.1 Check temperatures in incubators twice daily to ensure operation within stated limits (Reference 16.14).

9.2 Check thermometers at least annually against an NIST-certified thermometer or one traceable to NIST. Check mercury columns for breaks.

10.0 Quality Control (QC)

10.1 Pretest each batch of MI agar or broth for performance (i.e., correct enzyme reactions) with known cultures (E. coli, TC, and a non-coliform).

10.2 Test new lots of membrane filters against an acceptable reference lot using the method of Brenner and Rankin (Reference 16.7).

10.3 Perform specific filtration control tests each time samples are analyzed, and record the results.

10.3.1 Filter Control: Place one or more membrane filters on TSA plates, and incubate the plates for 24 hours at 35°C. Absence of growth indicates sterility of the filter(s).

10.3.2 Phosphate-Buffered Dilution Water Controls: Filter a 50-mL volume of sterile dilution water before beginning the sample filtrations and a 50-mL volume of dilution water after completing the filtrations. Place the filters on TSA plates, and incubate the plates for 24 hours at 35°C. Absence of growth indicates sterility of the

dilution water.
10.3.3 Agar or Broth Controls: Place one or more TSA plates and one or more MI agar plates or MI broth pad plates in the incubator for 24 hours at 35°C. Broth pad plates should be incubated grid-side up, not inverted like the agar plates. Absence of growth indicates sterility of the plates.
10.4 See recommendations on quality control for microbiological analyses in the "Manual for the Certification of Laboratories Analyzing Drinking Water: Criteria and Procedures; Quality Assurance" (Reference 16.15) and the USEPA Microbiology Methods Manual, part IV, C (Reference 16.6).

11.0 Procedure

11.1 Prepare agar or MI broth and TSA as described in Sections 7.5, 7.6, and 7.7. If plates are made ahead of time and stored in the refrigerator, remove them and allow them to warm to room temperature. The crystals that form on agar after refrigeration will disappear as the plates warm up (Reference 16.8).
11.2 Label the bottom of the agar or MI broth plates with the sample number/identification and the volume of sample to be analyzed. Label QC TSA plates and the MI agar or MI broth sterility control plate(s).
11.3 Using a flamed forceps, place a membrane filter, grid-side up, on the porous plate of the filter base. If you have difficulties in removing the separation papers from the filters due to static electricity, place a filter with the paper on top of the funnel base and turn on the vacuum. The separation paper will curl up, allowing easier removal.
11.4 Attach the funnel to the base of the filter unit, taking care not to damage or dislodge the filter. The membrane filter is now located between the funnel and the base.
11.5 Put approximately 30 mL of sterile dilution water in the bottom of the funnel.
11.6 Shake the sample container vigorously 25 times.
11.7 Measure an appropriate volume (100 mL for drinking water) or dilution of the sample with a sterile pipette or graduated cylinder, and pour it into the funnel. Turn on the vacuum, and leave it on while rinsing the funnel twice with about 30 mL sterile dilution water.
11.8 Remove the funnel from the base of the filter unit. A germicidal ultraviolet (254 nm) light box can be used to hold and sanitize the funnel between filtrations. At least 2 minutes of exposure time is required for funnel decontamination. Protect eyes from UV irradiation with glasses, goggles, or an enclosed UV chamber.
11.9 Holding the membrane filter at its edge with a flamed forceps, gently lift and place the filter grid-side up on the MI agar plate or MI broth pad plate. Slide the filter onto the agar or pad, using a rolling action to avoid trapping air bubbles between the membrane filter and the underlying agar or absorbent pad. Run the tip of the forceps around the outside edge of the filter to be sure the filter makes contact with the agar or pad. Reseat the membrane if non-wetted areas occur due to air bubbles.
11.10 Invert the agar petri dish, and incubate the plate at 37°C for 24 hours. Pad plates used with MI broth should be incubated grid-side up at 37°C for 24 hours. If loose-lidded plates are used for MI agar or broth, the plates should be placed in a humid chamber.
11.11 Count all blue colonies on each MI plate under normal/ambient light, and record the results (See Figures 1 and 2.). This is the E. coli count. Positive results that occur in less than 24 hours are valid, but the results cannot be recorded as negative until the 24-hour incubation period is complete (Reference 16.14).
11.12 Expose each MI plate to long wave ultraviolet light (366 nm), and count all fluorescent colonies [blue/green fluorescent E. coli, blue/white fluorescent TC other than E. coli, and blue/green with fluorescent edges (also E. coli)] (See Figure 1.). Record the data.
11.13 Add any blue, non-fluorescent colonies (if any) found on the same plate to the TC count (Reference 16.8).

12.0 Data Analysis and Calculations
12.1 Use the following general rules to calculate the E. coli or TC per 100 mL of sample:

12.1.1 Select and count filters with # 200 total colonies per plate.
12.1.2 Select and count filter with # 100 target colonies (ideally, 20-80).
12.1.3 If the total number of colonies or TC on a filter are too-numerous-to-count or confluent, record the results as "TC+ (TNTC)" and count the number of E. coli. If both target organisms are $ 200, record the results as "TC+ EC+ (TNTC)".
12.1.4 Calculate the final values using the formula:

$$\text{E.Coli/100ml} = \frac{\text{Number of blue colonies}}{\text{Volume of sample filtered}} * 100$$

$$\text{TC/100ml} = \frac{\text{No. florescent colonies+ No. of blue non-florescent colonies (if any)}}{\text{Volume of sample filtered}} *100$$

12.2 See the USEPA Microbiology Manual, Part II, Section C, 3.5, for general counting rules (Reference 16.6).
12.3 Report results as E. coli or TC per 100 mL of drinking water.

13.0 Method Performance

13.1 The detection limits of this method are one E. coli and/or one total coliform per sample volume or dilution tested (Reference 16.8).
13.2 The false-positive and false-negative rates for E. coli are both reported to be 4.3% (Reference 16.8).
13.3 The single lab recovery of E. coli is reported (Reference 16.8) to be 97.9% of the Heterotrophic Plate Count (pour plate) (Reference 16.2) and 115% of the R2A spread plate (Reference 16.2). For Klebsiella pneumoniae and Enterobacter aerogenes, two total coliforms, the recoveries are 87.5% and 85.7% of the HPC (Reference 16.8), respectively, and 89.3% and 85.8% of the R2A spread plate, respectively.
13.4 The specificities for E. coli and total coliforms are reported to be 95.7% and 93.1% (Reference 16.8), respectively.
13.5 The single lab coefficients of variation for E. coli and total coliforms are reported to be 25.1% and 17.6% (Reference 16.8), respectively, for a variety of water types.
13.6 In a collaborative study (References 16.4, 16.5, and 16.9), 19 laboratories concurrently analyzed six wastewater-spiked Cincinnati tap water samples, containing 3 different concentrations of E. coli (# 10, 11-30, and > 30 per 100 mL).
13.6.1 The single laboratory precision (coefficient of variation), a measure of the repeatability, ranged from 3.3% to 27.3% for E. coli and from 2.5% to 5.1% for TC for the six samples tested, while the overall precision (coefficient of variation), a measure of reproducibility, ranged from 8.6% to 40.5% and from 6.9% to 27.7%, respectively. These values are based on log10-transformed data (Reference 16.5).
13.6.2 Table 1 contains the statistical summary of the collaborative study (Reference 16.9) results.

14.0 Pollution Prevention

14.1 Pollution prevention is any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. It is the environmental management tool preferred over waste disposal or recycling. When feasible, laboratory staff should use a pollution prevention technique, such as preparation of the smallest practical volumes of reagents, standards, and media or downsizing of the test units in a method.
14.2 The laboratory staff should also review the procurement and use of equipment and supplies for other ways to reduce waste and prevent pollution. Recycling should be considered whenever practical.

15.0 Waste Management

15.1 Ghana Water Company Limited requires that laboratory waste management practices be consistent with all applicable rules and regulations. The Agency urges laboratories to protect the air, water, and land by minimizing and controlling releases from hoods and bench operations, complying with the letter and spirit of sewer discharge permits and regulations and by complying with solid and hazardous waste regulations, particularly the hazardous waste identification rules and land disposal restrictions. All infectious wastes should be autoclaved before disposal.

16.0 References

16.1 American Chemical Society. 1981. Reagent Chemicals. In American Chemical Society Specifications, 6th edition. American Chemical Society, Washington, D.C. For suggestions on the testing of reagents not listed by the American Chemical Society, see Analar Standards for Laboratory Chemicals, BDH Ltd., Poole, Dorset, U.K. and the United States Pharmacopeia.
16.2 American Public Health Association. 1992. Standard Methods for the Examination of Water and Wastewater, 18th edition. American Public Health Association, Washington, D.C.
16.3 American Society for Testing and Materials. 1993. Standard Specification for Reagent Water, Designation D1193-91, p. 45-47. In 1993 Annual Book of ASTM Standards: Water and Environmental Technology, Volume 11.01. American Society for Testing and Materials, Philadelphia, PA.
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16.10 Brenner, K.P., C.C. Rankin, M. Sivaganesan, and P.V. Scarpino. 1996. Comparison of the Recoveries of Escherichia coli and Total Coliforms from Drinking Water by the MI Agar Method and the U.S. Environmental Protection Agency-Approved Membrane Filter Method. Applied and Environmental Microbiology 62 (1): 203-208.
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Inorganic Chemicals and Microorganisms; Proposed Rule. Federal Register 50: 46936-47022.
16.13 Federal Register. 1994. National Primary and Secondary Drinking Water Regulations: Analytical Methods for Regulated Drinking Water Contaminants; Final Rule. Federal Register 59: 62456-62471.
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ADDITIONAL NOTES:
Changes to SOPs should be documented with a Change Log that accompanies the current version and captures the timeline and content of changes. A sample format is below:

Date:	Revision #:	Summary of Changes:	Submitted By:	Approved By/Date:	Effective Date:

ATTACHMENT 11: CORRECTIVE ACTION (CA) FORM

LABORATORY NAME: _____ GWCL ID: _____

DEPARTMENT OR ANALYSIS TYPE: _____

EVENT NAME / CATEGORY___ _____LOG # _____
Example names / categories: QC failure; PT failure; customer complaint; sample mishandled by lab; instrument malfunction; reporting error, etc. THE LOG NUMBER IS A UNIQUE IDENTIFIER ASSIGNED BY THE LABORATORY.

RESPONSIBLE SUPERVISOR / MANAGER: _____

PERSON COMPLETING CA FORM (NAME, TITLE): _____ DATE: _____

The QA Manager retains all Corrective Action reports in an organized system. The Log # is used to ensure all CAs are uniquely identified. Filing records by Log # is recommended; complete records will account for all Log #s. The Event Name/Category is used to track CAs for trends/patterns.

RECORD INFORMATION BELOW OR ATTACH ADDITIONAL SHEETS. PROVIDE DOCUMENTATION WHENEVER POSSIBLE.

EVENT DESCRIPTION:
Describe the nonconforming event or analysis result. Include details of staff member notified, date and time of notification, customer or outside involvement, analysis data, etc., as applicable. Attach any documentation that supports and/or supplements this description. If PT Failure, attach copy of PT report.

EVENT RESPONSE / INVESTIGATION STEPS:
Indicate the response(s) to the nonconformance, including all processes or raw data reviewed, QA or Management staff notified, analysis repeated, analysis halted, etc.

ROOT CAUSE DETERMINATION:
State the root cause (reason) for the nonconformance with the analysis or process.

CORRECTIVE ACTION (CA) FORM (cont'd)

ACTION(S) TAKEN TO RESOLVE ISSUE AND PREVENT RECURRENCE: *Include SOP revision, staff training, purchase of standards or equipment, document/form revision, etc.*

Corrective Action(s)	Contact Person Responsible	Proposed Implementation Date	Date Completed	Evidence Of Completion
Additional Comments/Supplemental Information:				

Submitted By:		Date:
Reviewed By:	Responsible Supervisor or Manager	Date:

By signature and comments below, the WQA Manager and Chief Manager-Water Quality Assurance approve this corrective action plan and the proposed implementation date(s) given. The QA Manager or designee will provide follow-up until the corrective action is closed with documentation/evidence of completion as noted above.

Approved By:	Regional Water Quality Assurance Manager	Date:
Approved By:	Chief Manager-Water Quality Assurance	Date:
Reviewer Comments or Additional Actions Recommended:		

Closing the Corrective Action: The QA Manager is responsible for effectiveness review. The CA should stay OPEN for a sufficient time to ensure all stated actions were taken and address/solve the initial issue.

Corrective Action Closed By QA Manager: Signature: _____ Date:_____

ATTACHMENT 12: SAMPLE BENCH SHEETS

SAMPLE TITRATION WORKSHEET

Method: _____ **Date and Time of Analysis**

Analyst: _____

Standardization

ml of std used		
Conc. of std in mg/L		
ml titrant		
Conc. of titrant, mg/L		

Purchase date standard	
Lot number	
Expiration date standard	
Supplier	

Sample Data

Sample number						
Sample adj. pH						
ml sample used						
Conc. of titrant						
Initial buret reading						
Final buret reading						
ml titrant used						
Sample conc mg/l						

Calculations:

Reviewed by:

SAMPLE FAECAL COLIFORM BENCH SHEET

Name of Facility	Date of Arrival:
Date of Sampling	Time of Arrival
Time of Sampling	Method Used
Exact Sample location	Time of Analysis
Sample preservation	Analyst
Signature of Sampler	

	Membrane Filter	Harlequin Agar/ Chromocult Agar	Absorbent Pads
Date of Purchase			
Lot number			
Date of Expiration			
pH			

Waterbath temperature (37.00 ± 0.2^{O}C)	
Time In:	Date In:
Temp In:	
Time Out:	Date out:
Temp Out:	

Filter Funnel Sterilized: (2-3 minutes minimum) Work area disinfected:

Positive control Organism used	Date purchased	Lot number	Expiration date	Result
Negative control Organism used	Date purchased	Lot number	Expiration date	Result

Dish	Sample volume (ml)	Colonies on membrane	CFU/100 ml	Plates used in count
Pre-blank				
1				
2				
3				
4				
5				
After blank				

Fecal Coliform cfu/100 ml

Lab Duplicate Analyses

Date	Sample	Analysis	analyst	First result	Second result	% difference

Spiked Sample Analysis

Date	Sample conc.	Sample vol.	Spike conc.	Spike vol.	Spike result	Calc.	% Recovery

Instrument Maintenance Log

Date	Tech	Instrument	Model #	Maintenance Performed	Reason

Lab Chemical Inventory

Chemical Name _____ Location _____

Date Received	Quantity	Supplier	Date Opened	Expiration Date	Date Emptied

Lab Reagent Preparation Log

Date	Reagent	Test	Tech.	Lot Number

ATTACHMENT 13: ETHICS POLICY STATEMENT

Ethics policy statement is developed by the laboratory and processes/procedures for educating and training personnel in their ethical and legal responsibilities including the potential punishments and penalties for improper, unethical, or illegal actions;

A vital part of the analytical laboratory services is their Laboratory Ethics Training Program. An effective program starts with an Ethics Policy Statement that is supported by all staff, and is reinforced with initial and ongoing ethics training.

A proactive ethics training program is the most effective means of deterring and detecting improper, unethical, or illegal actions in the laboratory. There are six facets to the program: (1) clearly define improper, unethical, and illegal actions; (2) outline elements of prevention and detection programs for improper, unethical, or illegal actions; and (3) identify examples of inappropriate (i.e., potentially fraudulent) laboratory practices; (4) Annual Ethics and Data Integrity Training to be documented and maintained in the personnel file of each employee., (5) Documented training on new revisions of the Quality Systems Manual (QSM) and for new employees as needed. (6) Signed Ethics and Data Integrity Agreement (to be completed for new employees and annually thereafter)

Definition of Improper, Unethical, and Illegal Actions

Improper actions are defined as deviations from contract-specified or method-specified analytical practices and may be intentional or unintentional.

Unethical or illegal actions are defined as the deliberate falsification of analytical or quality assurance results, where failed method or contractual requirements are made to appear acceptable.

Prevention of laboratory improper, unethical, or illegal actions begins with a zero-tolerance philosophy established by management. Improper, unethical, or illegal actions are detected through the implementation of oversight protocols.

Prevention and Detection Program for Improper, Unethical, or Illegal Actions

The (name of laboratory) management has implemented a variety of proactive measures to promote prevention and detection of improper, unethical, or illegal activities. The following components constitute the basic program:

- ⇨ An Ethics and Data Integrity Agreement that is read and signed by all personnel;
- ⇨ Initial and annual ethics training;
- ⇨ Internal audits;
- ⇨ Analyst notation and sign-off on manual changes to data;
- ⇨ A “no-fault” policy that encourages laboratory personnel to come forward and report fraudulent activities.

Examples of Improper, Unethical, or Illegal Practices

- ⇨ Improper use of manual integrations to meet calibration or method QC criteria
- ⇨ Intentional misrepresentation of the date or time of analysis (for example, intentionally resetting a computer system’s or instrument’s date and/or time to make it appear that a time/date requirement was met);
- ⇨ Falsification of results to meet method requirements;
- ⇨ Reporting of results without analyses to support

⇨ Selective exclusion of data to meet QC criteria (for example, initial calibration points dropped without technical or statistical justification);
⇨ Misrepresentation of laboratory performance by presenting calibration data or QC limits within data reports that are not linked to the data set reported, or QC control limits presented within QAPP that are not indicative of historical laboratory performance or used for batch control;
⇨ Notation of matrix inference as basis for exceeding acceptance limits (typically without implementing corrective actions) in interference-free matrices (for example, method blanks or laboratory control samples);
⇨ Unwarranted manipulation of computer software (for example, improper background subtraction to meet ion abundance criteria for GC/MS tuning, chromatographic baseline manipulations);
⇨ Improper alteration of analytical conditions (for example, modifying EM voltage, changing GC temperature program to shorter analytical run time) from standard analysis to sample analysis;
⇨ Misrepresentation of QC samples (for example, adding surrogates after sample extraction, omitting sample preparation steps for QC samples, over- or under-spiking); and
⇨ Reporting of results from the analysis of one sample for those of another.

TTACHMENT 14 LIST OF GHANA WATER COMPANY LIMITED LABORATORIES (REGIONAL AND SYSTEM LABORATORIES)

REGIONAL LABORATORIES

1. Greater Accra (ATMA) Regional Laboratory (Central Laboratory) –Accra
2. Ashanti Regional Laboratory – Suame, Kumasi
3. Western Regional Laboratory – Takoradi
4. Central Regional Laboratory – Cape Cost
5. Eastern Regional Laboratories – Koforidua
6. Northern Regional Laboratory – Tamale
7. Volta Regional Laboratory – Ho
8. Brong Ahafo Regional Laboratory - Sunyani
9. Upper East Regional Laboratory – Bolgatanga
10. Upper West Regional Laboratory – Wa

SYSTEM LABORATORIES

1. **GREATER ACCRA (ATMA)**
   - **a.** Kpong system laboratories
   - **b.** Weija system Laboratories
   - **c.** Keseve System Laboratory
2. **ASHANTI REGION**
   - **a.** Barekese system Laboratory
   - **b.** Owabi system Laboratory
   - **c.** Odaso System Laboratory
   - **d.** Konogo system Laboratory
   - **e.** Aframso System laboratory
   - **f.** Mampong Ssytem Laboratories
   - **g.** New Edubiase System Laboratory
3. **WESTERN REGION**
   - **a.** Inchaban System Laboratory
   - **b.** Daboase System Laboratory
   - **c.** Axim System Laboratory
   - **d.** Prestea System Laboratory
   - **e.** Bogoso System Laboratory
   - **f.** Bonsa System Laboratory
4. **CENTRAL REGION**
   - **a.** Brimsu System Laboratory
   - **b.** Kwonyako System Laboratory
   - **c.** Sekyere – Heman System Laboratory
   - **d.** Winneba System Laboratory
   - **e.** Baifikrom System Laboratory
   - **f.** Breman- Asikuma System Laboratory

g. Twifo Praso

5. EASTERN REGION

a. Bukunor System Laboratory
b. Koforidua Old Works System Laboratory
c. Nsawam System Laboratory
d. Kotoso System Laboratory
e. Asamankese System Laboratory
f. New Tafo System Laboratory
g. Kibi System Laboratory
h. Kwabeng System Laboratory
i. Apedwa System Laboratory
j. Bunso System Laboratory
k. Dodi System Laboratory
l. Osenase System Laboratory
m. Begoro System Laboratory
n. Anynam System Laboratory
o. Osino System Laboratory
p. Akim Oda System Laboratory

6. NORTHERN REGION

a. Dalun System Laboratory
b. Yendi System Laboratory

7. VOLTA REGION

a. Kpeve System Laboratory
b. Agbozume System Laboratory
c. Kpando System Laboratory
d. Hohoe System Laboratory
e. Juapong System Laboratory

8. BRONG AHAFO REGION

a. Abesim System Laboratory
b. Tanoso System Laboratory
c. Berekum System Laboratory
d. Biaso System Laboratory
e. Acherensua System Laboratory

9. UPPER EEST REGION

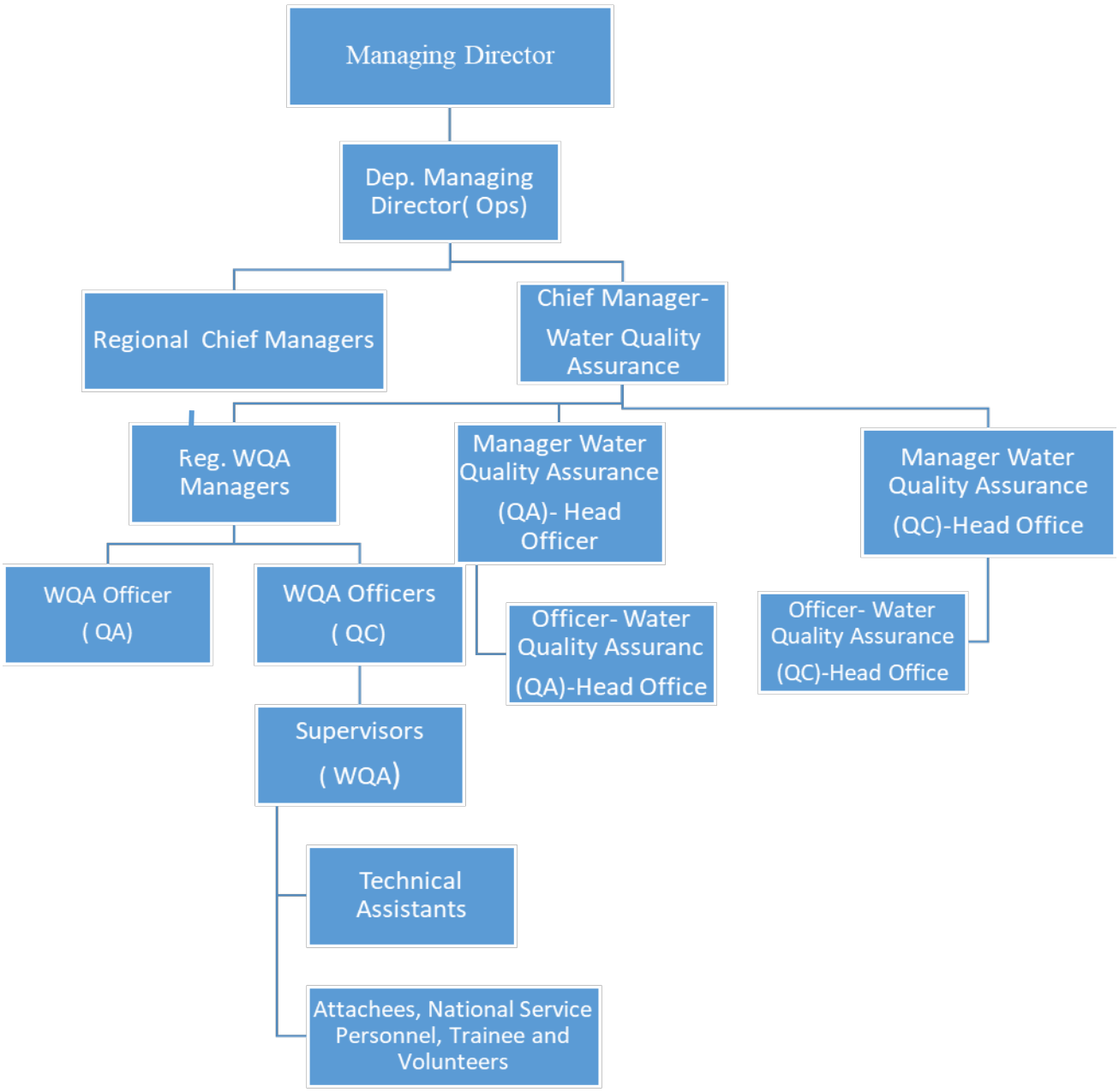
a. Bolgatanga (Vea) System Laboratory
b. Bawku System Laboratory
c. Navorongo System Laboratory

10. UPPER WEST REGION

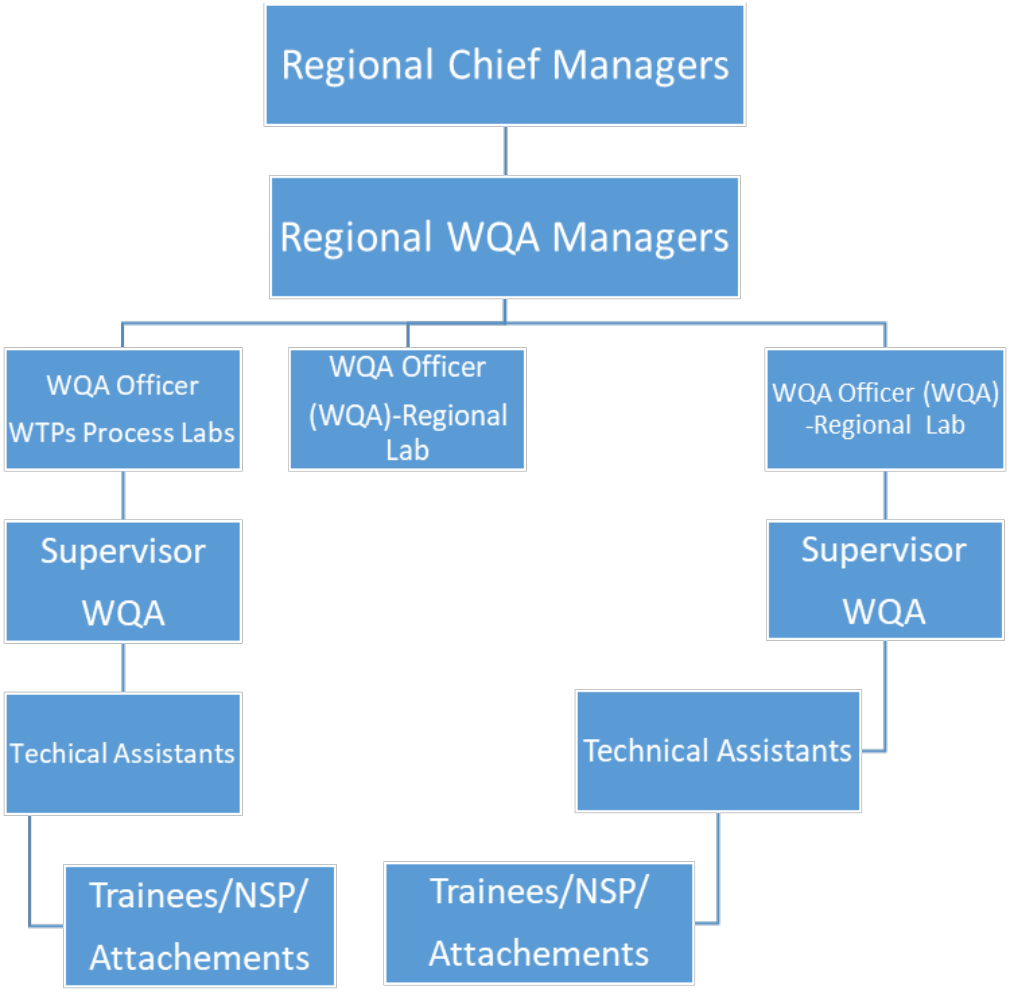
a. Jumabi System Laboratory

ATTACHMENT 15: NATIONAL AND REGIONAL ORGANIZATIONAL CHART FOR WQA DEPARTMENT

ATTACHMENT 15A: NATIONAL ORGANIZATIONAL CHART FOR WQA DEPARTMENT



ATTACHMENT 15B: REGIONAL ORGANIZATIONAL CHART FOR WQA DEPARTMENT



ATTACHMENT 16: LIST OF STAFF FOR THE WQA DEPARTMENT FROM THE REGIONS

ATTACHMENT 16A: LIST OF ASHANTI WATER QUALITY ASSURANCE STAFF

SUAME CENTRAL LABORATORY

#	NAME	DESIGNATION
1	Adam Yakubu	Snr. Water Quality Assurance Officer
2	Manuel Kofi Tetteh	Water Quality Assurance Officer
3	Emmanuel Yeboah	Snr. Supervisor WQA
4	Edna Mamle Tetteh	Assistant Water Quality Assurance Officer
5	Richard OwusuSiaw	Snr. Technical Assistant
6	Arhin Sarkodie Isaac	Jnr Technical Assistant WQA

BAREKESE SYSTEM LABORATORY

#	NAME	DESIGNATION
1	KwabenaAsiamah	Assistant Water Quality Assurance Officer
2	Lydia AgyeiwaaGyamfi	Snr. Technical Assistant
3	Daniel Ninfam	Snr. Technical Assistant
4	DominicNnkrumah	Technical Assistant
5	Florence Agyapong	Jnr. Technical Assistant

OWABIHEADWORKS

#	NAME	DESIGNATION
1	Angela NaaGyamahOdoi	Water Quality Assurance Officer
2	Eric Yeboah	Technical Assistant
3	Chris Dushie	Technical Assistant
4	Esther Sakyi	Jnr. Technical Assistant
5	Millicent Essel	Jnr. Technical Assistant

MAMPONG SYSTEM LABORATORY

#	NAME	DESIGNATION
1	Linda NaaBortey	Assistant Water Quality Assurance
2	Sandra Adu	Jnr. Technical Assistant
3	Rosemary Akwei	Jnr. Technical Assistant
4	Millicent Adjei	Jnr. Technical Assistant

KONONGO SYSTEM LABORATORY

#	NAME	DESIGNATION
1	Rudolf Awuley Mensah	Assistant Water Quality Assurance
2	Emmanuel Kodiah Okpoti	Snr. Technical Assistant
3	Reymond Mensah	Jnr. Technical Assistant

ODASO SYSTEM LABORATORY

#	NAME	DESIGNATION
1	Daniel Tei Ozor	Management Trainee
2	Kofi Aboagye Danquah	Jnr. Technical Assistant
3	Abdul Razak Karim	Jnr. Technical Assistant

AFRAMSO SESTEMS LABORATORY

#	**NAME**	**DESIGNATION**
1	Oscar Senya	Assistant Water Quality Assurance
2	Edward Danquah	Snr. Technical Assistant

ATTACHMENT 16B: LIST OF WEIJA HEADWORKS QUALITY ASSURANCE STAFF

LIST OF WATER QUALITY ASSURANCE STAFF –WEIJA HEADWORKS				
ITEM NO	**NAME**	**GRADE**	**REGION**	**STATION**
1	JOHN SUOBOGBIREE	WATER QUALITY OFFICER	ATMA PRODUCTION	WEIJA HEADWORKS
2	WILLIAM PUORU	WATER QUALITY OFFICER	ATMA PRODUCTION	WEIJA HEADWORKS
3	ISAAC TAWIAH-MENSAH	SUPERVISOR	ATMA PRODUCTION	WEIJA HEADWORKS
4	PAUL SENAHIA	SNR. TECH ASSIST	ATMA PRODUCTION	WEIJA HEADWORKS
5	ANTOINETTE INKOOM (MS)	TECH. ASSIST	ATMA PRODUCTION	WEIJA HEADWORKS
6	EMMANUEL DENTEH	JNR. TECH ASSIST	ATMA PRODUCTION	WEIJA HEADWORKS
7	ANITA TWUMBEA	JNR. TECH ASSIST	ATMA PRODUCTION	WEIJA HEADWORKS
8	DERRICK AMOAH	JNR. TECH ASSIST	ATMA PRODUCTION	WEIJA HEADWORKS
9	EMMANUEL ADU JNR.	JNR. TECH ASSIST	ATMA PRODUCTION	WEIJA HEADWORKS
10	**PRISCILLA ASARE**	**JNR. TECH ASSIST**	**ATMA PRODUCTION**	**WEIJA HEADWORKS**
11	**KINGSLEY SARFO**	**JNR. TECH ASSIST**	**ATMA PRODUCTION**	**WEIJA HEADWORKS**
12	**DANIEL O. LARTEY**	**JNR. TECH ASSIST**	**ATMA PRODUCTION**	**WEIJA HEADWORKS**
13	**LINDA TEYE (MS)**	**JNR. TECH ASSIST**	**ATMA PRODUCTION**	**WEIJA HEADWORKS**

ATTACHMENT 16C: GREATER ACCRA (ATMA) CENTRAL LABORATORY LIST OF STAFF

	Name	**Position**	**Qualification**
Senior Staff	1. Hanson Mensah-Akutteh	Regional Manager (WQA)	MSc. Public Health
	2. John G. Vitenu	Assist. Officer (WQA	BTech. (Science Lab. Tech)
	3. Justine A. Addo	Snr. Supervisor (WQA)	HND Science Lab Tech.
	4. Millicent A. Tetteh	Supervisor (WQA)	BTech. (Science Lab. Tech)
	5. Miriam Asare Donkor	Mgt Trainee (WQA)	BSc. Water & Sanitation
Junior Staff	6. Esi T. Odum	Snr. Tech. Assist (WQA)	BSc. Human Resource Mgt
	7. Gifty Botwe	Snr. Tech. Assist (WQA)	BSc Electrical Engineering
	8. Joseph A. Awinbisah	Jnr. Tech. Assist (WQA)	HND Science Lab Tech.
	9. Abraham Asoyele	Jnr. Tech. Assist (WQA)	WASSCE

ATTACHMENT 16 D: WATER QUALITY ASSURANCE STAFF IN EASTERN REGION

REGIONAL LABORATORY

#	NAME	DESIGNATION
1	Moses Abeiku Paintsil	Senior Water Quality Assurance Officer
2	Nafisah Mahama	Snr. Technical Assistant
3	Veronica Acquah	Jnr. Technical Assistant
4	Brian Tei Cudjoe	Jnr. Technical Assistant
5	Mavis Oduro Asante	Jnr. Technical Assistant
6	Mawulorm Akyere	Jnr. Technical Assistant
7	Delali Dornyo	Jnr. Technical Assistant

BUKUNOR HEADWORKS LABORATORY

#	NAME	DESIGNATION
1	Bismark Opoku Owiredu	Jnr. Technical Assistant
2	Doreen Opoku Owiredu	Jnr. Technical Assistant
3	Faustina Gborgbor	Jnr. Technical Assistant

NSAWAM HEADWORKS LABORATORY

#	NAME	DESIGNATION
1	Hilda Biney	Jnr. Technical Assistant
2	Josephine Armah	Jnr. Technical Assistant

AKIM ODA HEADWORKS LABORATORY

#	NAME	DESIGNATION
1	David Agbodzi	Assistant Technician
2	Abigail Frimpong	Jnr. Technical Assistant
3	Sandra Owusu	Jnr. Technical Assistant

KOTOSO HEADWORKS LABORATORY

#	NAME	DESIGNATION
1	Samuel Ansah	Jnr. Technical Assistant

LIST OF WQA STAFF FOR UPPER EAST WQA STAFF

NAME	GRADE	LOCATION
Asamoah Gyimah Evans	WQA Officer	Regional lab
Sherifatu Asumah	Snr Tech Assistant (WQA)	Regional lab
Mohammed Aisher Alhassan	Snr Artisan (WQA)	Regional lab
Catherine Asibi Baba	Jnr Tech Assistant (WQA)	Regional lab

ATTACHMENT 17: LIST OF LABORATORY EQUIPMENT WQA DEPARTMENT FROM THE REGIONS

ATTACHMENT 17A: LIST OF LABORATORY EQUIPMENT WQA DEPARTMENT FROM THE UPPER WEST REGION

Equipment	Brand	Model	Requirements	Date purchased	Status
Analytical weighing scale	Scientech	ZSL-600	Scale reads at least to 0.100 g	2016	Satisfactory
Standard reference weights	Griffin & George Ltd		ASTM class 1, 2 or 3. Not corroded		Satisfactory
Autoclave	Rexall Industries Co. Ltd	LS-2D	Capable of reaching and maintaining sterilization conditions (121 °C and 0.1 MPa). Reference Thermometer and pressures gauges: Temperature range 105-134°C Pressure Range 0.1-0.3MPa	Not available	Satisfactory
pH meter	HACH	HQ30d	Accurate to 0.1 pH units	2016	Satisfactory
pH standards buffers	HACH		pH buffer solutions: 4.0, 7.0 and 10.0 Bottles are labelled when received/open Discard after expiration date.	2016	Satisfactory
Spectrophotometer	HACH	DR 1900	HACH standards (depending on analysis)	2016	Unsatisfactory
Spectrophotometer	Merc	NOVA 60A	Merck standards (depending on analysis)	2017	Satisfactory
Dry air oven			Reference thermometer Temperature range: 20 – 200 °C		Satisfactory
Incubator	Fisher	55D	Reference thermometer Temperature range: 10 – 60 °C		Satisfactory
Fridge	Delron		Reference thermometer Temperature range: 0 – 20 °C	2016	Satisfactory
Thermometer		Glass-mercury	Scale: 1 °C Traceable to NIST or calibrated to SOP		Satisfactory
Turbidimeter	HACH	2100Q	Calibration standards: 10 NTU, 100 NTU, 800 NTU	2016	Satisfactory
Flocculator	Stuart	SW6	Speed range: 0 – 200 rpm		Not Functional
Conductivity meter	HACH	HQ30d	Calibration standard: 1 M NaCl solution	2016	Satisfactory
Colony counter	Stuart				Satisfactory
Hot plate	Sibata	NP-5			Satisfactory
Distillation plant	Barloworld Scientific Ltd	W4000			Satisfactory
TDS meter	Palintest	TDS6+		2017	Satisfactory

ATTACHEMENT 17B: LIST OF LABORATORY EQUIPMENT AND REFRENCE MATERIALS – EASTERN REGION

Name	Brand	Model	Requirement	Date Purchased	Status
Analytical weighing Balance	Adam	CQ7601	Scale reads at least 0.100g	2015	Satisfactory
Autoclave	Biobase	BKM- P24(D)	Capable of reaching and maintaining sterilization condition[121^{o}C and 0/1MPa]Reference Thermometer and pressure gauges Temperature range 121-126^{o}C.pressure range -0.1-0.14MPa	2018	Satisfactory
pH Meter	HACH	HQ411d	pH Buffer solutions: 4.0, 7.0, and 10.0. Accurate to 0.1pH units	2017	Satisfactory
Spectrophotometer	HACH	DR 6000	HACH standards (depending on analysis)	2017	Satisfactory
Hot Air Oven	Gallenkamp	SR2	Reference Thermometer Temperature range;30-200^{o}C	2005	Satisfactory
Spectrophotometer	HACH	DR 900	HACH standards (depending on analysis)	2016	Satisfactory
Incubator	Central kagaku	CB- 3DN	Reference Thermometer Temp Range: 10 – 50^{0}C	2008	Satisfactory
Fridge	Sanyo Medicool	GC-2495VS	Reference Thermometer Temperature range;4-32 ^{o}C.Station at well ventilated and on flat surface	2008	Satisfactory
Turbidity Meter	HACH	2100Q	Calibration Standards range ;0.00-9.99NTU 10.00-99.9NTU and 100.0-1000.0NTU	2013	Satisfactory
Flocculator	wagtech	SW1	Speed range: 0-200 rpm	2008	Satisfactory
Conductivity Meter	HACH	HQ14d	Calibration standard solution; KCL or NaCL[0.01]	2016	Satisfactory
Comparator	Nessleriser	2150		2013	Satisfactory
Distillation Plant	Nuckleon	SS-200		2017	Satisfactory
Comparator	Lovibond	2000		2015	Satisfactory
Hot Plate	Sibaca	NP5		2008	Satisfactory
Colony counter	Stuart Scientific	SC5		2013	Satisfactory

ATTACHMENT 18: CHECKLISTS FOR ON-SITE EVALUATION OF GHANA WATER COMPANY LIMITED

ATTACHMENT 18A: CHECKLISTS FOR ON-SITE EVALUATION OF GHANA WATER COMPANY LIMITED LABORATORIES – MICROBIOLOGY

MICROBIOLOGY

Laboratory	
Address	
City, Region	
Telephone No. Fax No.	
Audit Team Leader	
Audit Team Members	
Audit Team Affiliation	
Date	

Laboratory:_____ Evaluators: _____

Location_____ Date: _____

PHYSICAL FACILITY

Item	Acceptable Yes No	Comments
General Environment		
Heating/Cooling/Humidity		
Lighting		
Ventilation/Exhaust hoods		
Cleanliness		
Electrical and water services		
Work Space		
Separation of incompatible testing areas		
Controlled access where appropriate		
Housekeeping		
Unencumbered access		
Adequate work space		
Storage facilities		
Chemicals properly stored and dated		

Standards properly stored, dated and labeled with concentration, preparer's name and solvent, origin, purity & traceability		
Computers & automated equipment		
Safety procedures		

Laboratory:_____ **Evaluators:** _____

Location:_____ **Date:**_____

PERSONNEL (Use additional paper if necessary.)

Position/ Title	**Name**	**Education Level**	**Specialized Training**	**Present Specialty**	**Experience**
Regional Water Quality Manager (Head of Laboratory)					
Water Quality Officers					
WQA Supervisors					
Instrument Operators					
National Service					
		Yes No	Comments		

An organization chart for the laboratory available		
Lab manager has line authority		
Personnel job descriptions and resumes available		
Personnel training documented		

Laboratory:_____**Evaluator** _____

Location_____**Date** _____

QUALITY ASSURANCE AND DATA REPORTING

Item	**Comments**	**Satisfactory** **Yes** **No** **(NA if not applicable)**	
QA plan			
Organization			
Sampling SOPs available and used Preservation Containers Holding times Samplers trained			
Sample Rejection			
Laboratory sample handling Log in procedure Bound log book or secure computer log in Storage Tracking Chain of custody			

Item	Comments	Satisfactory Yes (NA if not applicable)	Satisfactory No (NA if not applicable)
Analytical Methods Written methods available Approved methods used SOPs available and used			
Calibration Type and frequency Source of standards			
Blanks Trip Field Method			
Method Detection Limits Initial Frequency Acceptability			
Precision and Accuracy Initial Frequency Acceptability Control charts Laboratory fortified blanks Matrix duplicates			
The laboratory analyst, at least annually performance evaluation samples within limits Performance evaluation study records are maintained Corrective action is documented where performance problems are indicated by the study results			No
Records Retention and Data Management			
Personnel Qualifications/Training: 1. Has the analyst demonstrated acceptable results on unknown or PT samples before analyzing			

Item	Comments	Satisfactory Yes No (NA if not applicable)	
compliance samples? 2. Can the laboratory produce Training Files for all laboratory personnel? **3.** Can the laboratory supervisor demonstrate that all laboratory personnel have the ability to satisfactorily perform the analyses to which they are assigned?			
Corrective Action			

Element	Yes	No	NA	Comments
Personnel				
Supervisor				
The supervisor has education or job experiences sufficient to provide leadership and oversight of laboratory operations.				
The supervisor can document that all lab staff have the ability to satisfactorily perform the analyses to which they are assigned.				
Laboratory maintains personnel records on laboratory analysts that include academic background and types of training completed.				
Analyst				
Analysts have education and training to satisfactorily perform the analyses to which they are assigned.				

Facilities				
Lab facilities are clean, temperature and humidity controlled.				
Incompatible testing areas are separated.				
Access is controlled when necessary and traffic flow is minimized through work areas.				
Benchtops and floors are easily cleaned and disinfected.				
Lab has sufficient space for processing samples; media and glassware storage and areas for cleaning glassware and sterilizing materials.				
Lab has provisions for disposal of microbiological wastes.				
Laboratory equipment and supplies				
The laboratory has the equipment and supplies needed to adequately analyze water samples.				
pH meter				
Meter measures to 0.1 units				
Meter is standardized each use period with pH 7.0 and either 4.0 or 10.0 standard buffers, with date and standards used recorded in log book.				
pH standard buffers are discarded by expiration date.				
Balance (top loader or pan)				
Balance readability of 0.1 gram				
Balance calibrations is checked on a regular basis and with standard reference weights, or non-standard weights that are calibrated against reference weights.				
Balance use and calibrations checks				

recorded.				
Temperature Monitoring Devices				
35ºC incubator thermometers are graduated in 0.5ºC increments, or less.				
44ºC water bath thermometers are graduated in 0.2ºC increments.				
No separation of fluid column in glass thermometers.				
Thermometers calibrated annually at the temperature used against a traceable reference thermometer.				
Calibration factor marked on thermometer and calibrations recorded in log book.				
Incubator Unit				
Incubators have an internal temperature monitoring device and maintain temperature of 35 +/- 0.5ºC.				
Incubators or water baths used for 44ºC incubation have a temperature monitoring device and maintain temperature.				
Glass thermometers in incubators have bulbs immersed in liquid.				
Calibration-corrected temperature recorded twice daily for days in use.				
Autoclave				
Autoclave has an internal heat source, temperature gauge, pressure gauge and operational safety valve.				
Autoclave capable of maintaining sterilization temperature (121ºC) during sterilizing cycle and completes a cycle in 45 minutes when a 12-15 minute sterilization period is used.				
Autoclave can depressurize slow enough				

to avoid media boiling over.				
The following information is recorded for each sterilization cycle: -Date -Contents -Sterilization time and temperature -Total time in autoclave -Analyst's initials				
A maximum-temperature-registering thermometer or continuous recording device is used each cycle to document that proper temperature was reached.				
Autoclave performance is checked regularly to confirm sterilization conditions are achieved.				
Hot Air Oven				
Oven maintains sterilization temperature of 170- 180ºC for at least two hours.				
Thermometer is graduated in 10ºC increments or less and bulb is placed in sand during use.				
The following information is recorded for each cycle: -Date -Contents -Time and temperature -Analyst's initials				
Oven performance is checked regularly to confirm sterilization conditions are achieved.				
Colony Counter				
Dark field colony counter is used to count Heterotrophic Plate Count colonies.				
Conductivity Meter				
Meter is used to check lab reagent-grade				

water.				
Refrigerator				
Maintains temperature of 1-5ºC.				
Thermometer used in refrigerator is graduated in at least 1ºC increments and bulb is immersed in liquid.				
Calibration-corrected temperature is recorded at least once a day.				
Inoculating Equipment				
Proper inoculating equipment is used (e.g. nickel/platinum wire loops or wood sticks or sterile plastic loops)				
Membrane Filtration Equipment				
MF filter funnels/bases are made of stainless steel, glass, or autoclavable plastic.				
If graduations on funnels are used to measure sample volume, their accuracy has been checked with a graduated cylinder and records are available				
All membrane filters are cellulose ester, white, grid marked, 47mm diameter and 0.45um pore size.				
Filters are purchased pre-sterilized or sterilized for 10 minutes ate 121ºC.				
Filter lot numbers and date received are recorded.				
Forceps are blunt with no corrugations on the inner sides of the tips.				
Culture Dishes				
Glass culture dishes are sterilized wrapped in paper or aluminum foil or in aluminum canisters.				
Each batch of glass culture dishes are				

checked for sterility.				
Pipets				
Glass pipets are sterilized wrapped in paper or aluminum foil or in aluminum/stainless steel canisters.				
Pipets are free from chips and cracks and markings are legible.				
Pipets are available in appropriate sizes for the types of liquid measurements required.				
Pipet ends are plugged with cotton.				
Micropipettes are calibrated on a regular basis and this calibration is recorded.				
Sterilization temperature/time				
Glassware/ Plastic ware				
Glassware is borosilicate glass and free of chips and cracks.				
Graduated cylinders have legible markings and appropriate sizes are available for the types of liquid measurements required.				
Culture tubes for fermentation medium are of sufficient size to contain medium plus sample without being more than three quarters full.				
Sample Containers				
Sample containers are wide-mouthed plastic or non-corrosive glass bottles with non-leaking glass stopper or caps with non-toxic liners, or sterile plastic bags or other appropriate sample containers.				
Sample containers for bacteriological samples contain sodium thiosulfate or some other chlorine-neutralizing chemical.				
Sample containers for bacteriological				

samples have a capacity of at least 120 ml to allow for at least a one-inch headspace.				
At least one container from each batch of sterilized sample containers is checked for sterility using a non-selective growth medium.				
General Laboratory Practices				
The laboratory staff perform their duties using customary safety practices.				
Sterilization Procedures				

ATTACHMENT 18B: CHECKLISTS FOR ON-SITE EVALUATION OF GHANA WATER COMPANY LIMITED LABORATORIES – CHEMISTRY

CHEMISTRY

Laboratory	
Address	
City, Region	
Zip	
Telephone No. Fax No.	
Audit Team Leader	
Audit Team Members	
Audit Team Affiliation	
Date:	

Laboratory: **Evaluators: _____**

Location_____Date: _____

PHYSICAL FACILITY

Item	Acceptable Yes No	Comments
General Environment		
Heating/Cooling/Humidity		
Lighting		
Ventilation/Exhaust hoods		
Cleanliness		
Electrical and water services		
Work Space		
Separation of incompatible testing areas		
Controlled access where appropriate		
Housekeeping		
Unencumbered access		
Adequate work space		
Storage facilities		

Chemicals properly stored and dated		
Standards properly stored, dated and labeled with concentration, preparer's name and solvent, origin, purity & traceability		
Computers & automated equipment		
Safety Procedures		

Laboratory: _____ **Evaluators:** _____

Location:_____**Date:** _____

PERSONNEL (Use additional paper if necessary.)

Position/ Title	**Name**	**Education Level**	**Specialized Training**	**Present Specialty**	**Experience**
Regional Water Quality Manager (Head of Laboratory)					
WQA Officer					
WQA Supervisors					
Technical Assistants					
Instrument Operators					
Instrument Operators					
Instrument Operators					

	Yes	No	Comments
An organization chart for the laboratory available			
QA manager has line authority			
Personnel job descriptions and resumes available			
Personnel training documented			

Laboratory: **Evaluators: _____**

Location:_____Date: _____

QUALITY ASSURANCE AND DATA REPORTING CHECK LIST

Item	Comments	Satisfactory Yes (NA if not applicable)	No
QA plan			
Organization			
Sampling SOPs available and used Preservation Containers Holding times Samplers trained			
Sample Rejection			
Laboratory sample handling Log in procedure Bound log book or secure computer log in Storage Tracking Chain of custody			
Analytical Methods Written methods available Approved methods used SOPs available and used			
Calibration Type and frequency Source of standards			
Blanks Trip Field Method			
Method Detection Limits Initial Frequency Acceptability			
Precision and Accuracy Initial Frequency Acceptability			

Item	Comments	Satisfactory Yes No (NA if not applicable)	
Control charts Laboratory fortified blanks Matrix duplicates			
The laboratory analyst, at least annually performance evaluation samples within limits Performance evaluation study records are maintained Corrective action is documented where performance problems are indicated by the study results			
Records Retention and Data Management			
Personnel Qualifications/Training: 4. Has the analyst demonstrated acceptable results on unknown or PT samples before analyzing compliance samples? 5. Can the laboratory produce Training Files for all laboratory personnel? **6.** Can the laboratory supervisor demonstrate that all laboratory personnel have the ability to satisfactorily perform the analyses to which they are assigned?			
Corrective Action			

Laboratory: **Evaluators: ___**

Location_____Date:

Item	No. of Units	Method	Manufacturer	Model	Satisfactory Yes (NA if not applicable)	No
Analytical Balance 0.1 mg readability Stable base ASTM type 1 or 2 weights (formerly Class S) Service contracts						
pH Meter Accuracy ±0.1 units Line or battery Usable with specific ion electrodes						
Conductivity Meter Readable in ohms or mhos Range of 2 ohms to 2 mhos Line or battery						
Hot Plate - temp control						
Color Standards To verify wavelengths photometers Should cover 200-800 nm						
Refrigerator/Freezer Standard laboratory, explosion proof for organics						

Item	No. of Units	Method	Manufacturer	Model	Satisfactory Yes (NA if not applicable)	Satisfactory No (NA if not applicable)
Capable of maintaining nominal temperature of 4C						
Drying Oven Gravity or convection Controlled from room temp to 180°C or higher(±2°C)						
Muffle Furnace To 450°C for cleaning organic glassware						
Thermometer Mercury filled Celsius 1°C or finer subdivision to 180°C NBS Certified or traceable						
Glassware Borosilicate Volumetric should be Class A Burette						
Spectrophotometer Range (HACH?) 400 - 700 nm Band width - < 20 nm Use several size & shape cells Path length 1 - 5 cm						

Laboratory: **Evaluators:**

Location_____Date:

METHODOLOGY

Contaminant	**Method(s)** Name/Number and revision	**Reference** Cite source, year, page	**Samples/Mo**	**Satisfactory** **Yes** **No** **(NA-not applicable)**	
pH					
Colour					
Turbidity					
Electrical Conductivity					
Total Dissolved Solids					
Salinity					
Dissolved O_2					
Alkalinity					
Calcium					
o-Phosphate					
Total Hardness					
Nitrate					
Nitrite					
Chlorine					

Contaminant	**Method(s)** Name/Number and revision	**Reference** Cite source, year, page	**Samples/Mo**	**Satisfactory** **Yes** **No** **(NA-not applicable)**	
Chloride					
Fluoride					
Iron					
Manganese					
Copper					
Arsenic					
Cadmium					
Lead					
Odour					
Residual Chlorine test					
Chlorine Demand test					
Flocculation/Jar test					
Marble Test (Corrosivity and aggressivity)					
Sulfate					
TDS					

Contaminant	**Method(s)** Name/Number and revision	**Reference** Cite source, year, page	**Samples/Mo**	**Satisfactory** **Yes** **No** **(NA-not applicable)**	
Silica					
Organic Matter					

SAMPLE COLLECTION Documentation

Item	Comments	Observations	
Trained Sample Collector			
Samples exceeding holding times discarded			
Sampling Plan			
Sampling forms (Field Report forms)			
Sample Identification (Proper Labeling)			
Sample Handling and transportation			

SAMPLE HANDLING AND PRESERVATION

Contaminant	**Container** material & size	**Preservatives**	**Holding Time** Sample	Extract	**Satisfactory** **Yes**	**No**

DRINKING WATER RECORD KEEPING AUDIT

SAMPLE CHECKLIST			
Field Records	**Yes**	**No**	**Comments**
1.1 Field Sampling			
Are the samples collected properly documented and identified?			
1.2 Field Measurements*			
Are the samples analyzed in the field properly documented and identified?			
1.3 Sample Acceptance			
Is a sample receiving logbook or equivalent system used to record the chronology of sample entry into the laboratory?			
Does the lab use a Chain of Custody to receive the samples?			
Documentation of samples received; acceptance and rejected			
Preservatives/holding times			
1.4 Sample Storage			
Samples requiring special handling are properly stored (i.e., light sensitive, temperature sensitive, radioactive)			

CHEMISTRY LABORATORY ANALYSIS REVIEW CHECKLIST			
Laboratory Records	**Yes**	**No**	**Comments**
2.1 Analytical Methods			**Effective Date:**
Analytical methods (SOPs) are up to date, listed and referenced in the laboratory's Quality Manual for all analytes measured and this listing accurately reflects the analytical methods employed by the laboratory and are used.			**Page 121 of 126**
2.2 Instrument Performance			
Laboratory monitors and documents instrument performance characteristics regularly, in accordance with the method specifications and the equipment manufacturer's recommendations			
Instrument performance records are maintained and include the following items:			
• Initial demonstration of capability			
• Determination of linear dynamic range (This only applies if a calibration curve is being run)			
• Method Detection Limits (if applicable)			
• Performance on standard reference materials and/or QC check samples			
Laboratory equipment such as analytical balances, Turbidimeters, Spectrophotometers and thermometers are calibrated against standards traceable to NIST			
Equipment stability records such as dry oven, incubator, refrigerator, autoclave, and block digester temperatures are maintained. Records of maintenance available?			
2.3 Initial Demonstration of Capability			
Method performance is demonstrated/validated as specified by the published method or if not specified, A minimum of four replicates of a quality control or reference sample are processed through all steps of the analytical procedure			
Initial method precision and bias criteria are met			
The method is validated for each analyst and each instrument the analyst uses with documentation			
MDLs are calculated for all analytes when possible.			

CHEMISTRY LABORATORY ANALYSIS REVIEW CHECKLIST			
Laboratory Records	**Yes**		**Comments**
2.3.1 Method Precision and Bias			
Method precision and bias control limits are met for all analytes measured			
Precision records/documentation are maintained for each instrument and each test			

Quality Control charts (% recovery vs time) are maintained or QC limits calculated			
Corrective action is documented and re-analysis results are reported where precision and bias limits fall outside acceptable ranges			
Does the analyst and verification review include at least the following procedures? – the results meet the laboratory-specific QC criteria; – the appropriate sample preparatory and analytical procedures and methods were followed, and that chain-of-custody and holding time requirements were met; – Checks to ensure that all calibration and QC requirements were met; – Checks for complete and accurate explanations of anomalous results, corrections, and the use of data qualifiers in the case narrative;			
Do data reviews consist of 100% review by the analyst, 100% verification review by a technically qualified supervisor or data review specialist, and a final administrative review?			
2.3.2 Method Detection Limits(if applicable)			
Method detection limits (MDLs) are measured for all analytical methods if applicable			
Each analyst measures their own detection limit for each analytical method and instrument used in the procedure			
MDL records are maintained			
2.4 Initial Instrument Calibration (if applicable)			
Instruments are calibrated for all analytes measured	Yes		
Analytes are measured at concentrations covering the sample concentration range			
Instruments are calibrated at the correct frequency as specified by the method and/or the instrument manufacturer's recommendations			
Calibration records are maintained for each instrument			
Continuing Instrument Calibration			
Calibration check standards are routinely measured and			

documented as specified by the published method			
Corrective action (recalibration) is documented and re-analysis results are recorded where check standard results do not meet method criteria			
2.5 Routine performance checks			
Quality control (QC) or referenced materials are analyzed quarterly or as specified by the published method			
LFBs (LCS) are analyzed for all analytes measured at the required concentration and frequency			
Method bias (% recovery) criteria is met for all analytes measured.			
Performance check records are maintained and include the following items:			
2.6 Titrations			
Reagents stored properly and standardized as per SOP.			
Standards and a blank run before analysis			
QC checks are run per sample batch (usually every 20 samples or less); e.g duplicates, matrix spike, reference standards			
Standards and a blank run at end of analysis			
2.**6 Instrument Maintenance**			
Instrument maintenance schedules from manufacturers are followed and maintenance activities are documented (log book)			
Repair activities are recorded for all instruments			
3.0 Health and Safety /Emergency Preparedness			
Eating, drinking, using tobacco products, applying of cosmetics, or taking medicine, occur only outside the lab (these activities prohibited in lab)?			
Appropriate lab attire worn (lab coats, no shorts, no open-toed shoes, etc)			
Specialized eye protection (for lasers) or other specialized safety devices used properly			

Are unattended reactions forbidden or minimized and properly structured			
A lab phone available with emergency phone numbers posted? #4.2 Is a lab safety shower/eyewash available			
Safety equipment available and operational (fire extinguisher, fire aid kits, etc.)			
Safety shower/eyewash available and thoroughly tested at least monthly, with reminder sheet posted			
Safety equipment easily accessible (NOT blocked or obstructed)			
Egress routes from lab established, not blocked, and known to all staff.			
Special hoods or ventilation devices available (perchloric acid hoods, etc) working properly and independently tested			
4.0 Laboratory Waste Management/Disposals			
normal trash waste streams categorized, labeled, covered, and disposal methods established			
Chemical/hazardous waste streams categorized, labeled, covered, and disposal methods established			
Microbiological waste streams categorized, labeled, covered, and disposal methods established			
Non-contaminated sharps and glass waste streams categorized, labeled, covered, and disposal methods established			
Are waste chemicals stored in secondary containment until pickup in case of leaks or spillage			

DRINKING WATER RECORD KEEPING AUDIT

SAMPLE CHECKLIST			
Field Records	**Yes**	**No**	**Comments**
1.1 Field Sampling			
Are the samples collected properly documented and			

identified?			
1.2 Field Measurements*			
Are the samples analyzed in the field properly documented and identified?			
1.3 Sample Acceptance			
Is a sample receiving logbook or equivalent system used to record the chronology of sample entry into the laboratory?			
Does the lab use a Chain of Custody to receive the samples?			
Documentation of samples received; acceptance and rejected			
Preservatives/holding times			
1.4 Sample Storage			
Samples requiring special handling are properly stored (i.e., light sensitive, temperature sensitive, radioactive)			

ATTACHEMENT 19: MEMBERSHIP OF COMMITTEE FOR DRAFTING THE QUALITY ASSURANCE MANUAL AND POLICY DOCUMENT FOR THE OPERATIONS OF THE QUALITY ASSURANCE DEPARTMENT

No	Name	Grade	Region	Status
1	Mrs. Margaret Macaulay	Chief Manger -WQA	Head Office	Advisor
2	Mr. Moses A. Abeiku	Senior WQA Officer	Eastern	Chairman
3	Mr. John G. Vitenu	Asst WQA Officer	ATMA Prod.	Member
4	Mr. Adam Yakubu	Senior WQA Officer	Ashanti Prod.	Member
5	Mr. Mark T. Ayertey	WQA Officer	Head Office	Member/Secretary/Coordinator
6	Mr. Hanson Mensah-Akutteh	Reg. WQA Manager	ATMA Prod.	Member (Co-opted)