PROTOCOL FOR THE VERIFICATION OF MERCURY AMALGAM REMOVAL TECHNOLOGIES

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with support from the
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FOREWORD

In 1995, the U.S. Environmental Protection Agency (EPA) instituted a program, the Environmental Technology Verification Program (ETV), to verify the performance characteristics of commercial-ready environmental technologies through the evaluation of objective and quality-assured data. Managed by EPA's Office of Research and Development, ETV was created to substantially accelerate the entrance of innovative environmental technologies into the domestic and international marketplaces. ETV provides purchasers and permitters of technologies with an independent and credible assessment of the technology they are purchasing or permitting.

During its pilot phase, EPA has cooperatively managed twelve ETV pilots in conjunction with partner organizations, including states, federal laboratories, associations, and private sector testing and standards organizations. The pilots have focused on each of the major environmental media and various categories of environmental technologies and have been guided by the expertise of a Stakeholder Group. Stakeholder Groups consist of representatives of all verification customer groups for the particular technology sector, including buyers and users of technology, developers and vendors, state and federal regulatory personnel, and consulting engineers. All technology verification activities are based on testing and quality assurance protocols that have been developed with input from the major stakeholder/customer groups.

NSF International is an independent, not-for-profit organization, dedicated to public health, safety, and protection of the environment. NSF develops standards, provides educational services, and offers superior third-party conformity assessment services, while representing the interests of all stakeholders. In addition to well-established standards-development and certification programs, NSF specifically responds to and manages research projects, one-time evaluations and special studies.

NSF is the verification partner organization for three pilots under EPA's ETV Program: Drinking Water Systems, which has completed the pilot stage and is now a center, Wet Weather Flow Technologies, and Source Water Protection Technologies. This Protocol for the Verification of Mercury Amalgam Removal Technologies was developed under the Source Water Protection Pilot, whose goal is to verify the performance of commercial-ready technologies used to protect ground and surface waters from contamination. Testing conducted under the ETV program using this protocol does not constitute an NSF or EPA certification of the product tested. Rather, it recognizes that the performance of the equipment has been determined and verified by these organizations.

Verification differs from certification in that it employs a broad, public distribution of test reports and does not use pass/fail criteria. In addition, there are differences in policy issues relative to certification versus verification. Certification, unlike verification, requires auditing of manufacturing facilities, periodic retesting, mandatory review of product changes and use of the NSF Mark. Both processes are similar, however, in regard to having standardized test methods

and independent performance evaluations and test result preparation. This protocol is subject to revision; please contact NSF to confirm this revision is current.

ACKNOWLEDGEMENTS

EPA and NSF acknowledge and thank those persons who participated in the preparation and review of this *Protocol for the Verification of Mercury Amalgam Removal Technologies*. Without their hard work and dedication to the project, this document would not have been approved through the process that has been set forth for this ETV project.

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GLOSSARY OF TERMS

Accuracy - a measure of the closeness of an individual measurement or the average of a number of measurements to the true value and includes random error and systematic error.

Bias - the systematic or persistent distortion of a measurement process that causes errors in one direction.

Commissioning – the installation of the mercury amalgam removal technology (free of mercury residuals) and start-up of the technology using test site wastewater.

Comparability – a qualitative term that expresses confidence that two data sets can contribute to a common analysis and interpolation.

Completeness – a qualitative term that expresses confidence that all necessary data have been included.

Owner – the owner of a dental office used as a test site for verification testing.

Precision - a measure of the agreement between replicate measurements of the same property made under similar conditions.

Protocol – a written document that clearly states the objectives, goals, scope and procedures for the study. A protocol shall be used for reference during Vendor participation in the verification testing program.

Quality Assurance Project Plan – a written document that describes the implementation of quality assurance and quality control activities during the life cycle of the project.

Residuals – the waste streams, excluding final effluent, which are retained by or discharged from the technology.

Representativeness - a measure of the degree to which data accurately and precisely represent a characteristic of a population parameter at a sampling point or for a process conditions or environmental condition.

Source Water Protection Stakeholder Advisory Group - a group of individuals consisting of any or all of the following: buyers and users of mercury amalgam removal and other technologies, developers and vendors, consulting engineers, the finance and export communities, and permit writers and regulators.

Standard Operating Procedure – a written document containing specific procedures and protocols to ensure that quality assurance requirements are maintained.

Technology Panel - a group of individuals with expertise and knowledge in mercury amalgam removal technologies.

Test Plan – a written document that describes the procedures for conducting a test or study according to the verification protocol requirements for the application of mercury amalgam removal equipment at a particular test site. At a minimum, the Test Plan shall include detailed instructions for sample and data collection, sample handling and preservation, precision, accuracy, goals, and quality assurance and quality control requirements relevant to the particular dental office test site.

Testing Organization – an independent organization qualified to conduct studies and testing of mercury amalgam removal technologies in accordance with protocols and test plans. A list of qualified Testing Organizations shall be maintained by the Verification Organization.

Vendor – a business that assembles or sells mercury amalgam removal equipment.

Verification – to establish the evidence on the performance of mercury amalgam removal technologies under specific conditions, following a predetermined study protocol(s) and test plan(s).

Verification Organization – an organization qualified by USEPA to verify Test Plans and Verification Reports, and to issue Verification Statements.

Verification Report – a written document prepared by the Testing Organization containing all raw and analyzed data, all QA/QC data sheets, descriptions of all collected data, a detailed description of all procedures and methods used in the verification testing, and all QA/QC results. The Test Plan(s) shall be included as part of this document.

Verification Statement – a document that summarizes the Verification Report reviewed and approved by the Verification Organization on behalf of USEPA, or directly by USEPA.

ABBREVIATIONS AND ACRONYMS

ANSI	American National Standards Institute
ASQC	American Society for Quality Control
DQI	data quality indicators
ETV	Environmental Technologies Verification
MSDS	material safety data sheets
NSF	NSF International
O&M	operational and maintenance
ORD	Office of Research and Development
OSHA	Occupational Safety and Health Administration
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
QMP	quality management plan
SOP	standard operating procedure
TCLP	toxicity characteristic leaching procedure
USEPA	United States Environmental Protection Agency

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1.0 INTRODUCTION

This document contains the generic protocol to be employed for the verification testing of mercury amalgam removal technologies used for the removal of mercury from dental wastewater at individual dental offices. The protocol has been prepared under the United States Environmental Protection Agency (USEPA) Environmental Technologies Verification (ETV) program.

1.1 The Environmental Technologies Verification Program

The ETV Program was established by the United States Environmental Protection Agency (USEPA) and is intended to:

- evaluate the performance of innovative and commercially available environmental technologies;
- provide permit writers, buyers and users, among others, with objective information about technology performance; and,
- facilitate "real world" implementation of promising technologies.

The verification testing protocol is intended to serve as a template for conducting verification tests for various technologies. The goal of the verification testing process is to generate high quality data for verification of equipment performance.

The ETV Program is subdivided into twelve individual pilot projects, one of which is the Source Water Protection Pilot. This Pilot includes the verification testing of mercury amalgam removal technologies appropriate for the removal of amalgam and mercury from wastewater produced by dental practices.

NSF International is overseeing the verification testing pilot project for mercury amalgam removal technologies with the participation of vendors, under the sponsorship of the USEPA Office of Research and Development (ORD). The role of NSF is to provide technical and administrative leadership in conducting the testing.

It is important to note that verification of the equipment does not mean that the equipment is "certified" by NSF or USEPA. Instead, the verification testing pilot projects are a formal mechanism by which the performance of equipment can be determined by these two Agencies, and which can result in the issuance of a Verification Statement by NSF/USEPA.

1.2 Objectives of Verification Testing

The general and specific objectives of the proposed verification testing should be specific to the treatment claims made by the Vendor and the desired Verification Statement.

In general, the objectives of verification testing shall be to determine the following:

- the performance of a specific mercury amalgam removal technology relative to the Vendor's stated range of technology capabilities, operating under field conditions;
- the necessary inputs (power, chemicals, labor, etc.) and the operating costs of the technology; and,
- the range of operating conditions and the ease of operation and maintenance of the equipment.

Verification testing conducted at a single site may not represent the complete range of treatment capabilities of the technology being tested. However, it will provide quality assurance to enable potential users of the technology to determine the applicability of the technology for the treatment of similar dental wastewaters.

1.3 Purpose and Scope of Protocol

This document contains guidance to Testing Organizations, Vendors and test facility Owners for verification testing of mercury amalgam removal technologies. Instructions are provided for preparation of Test Plans, execution of testing, data management and analysis, and reporting.

Adherence to the guidelines presented in this document is intended to provide sufficient information to the Verification Organization to make a determination about the performance of particular technologies tested at specific sites, and can lead to issuance of a Verification Statement.

1.4 Verification Testing Process

The verification testing process consists of three phases, as shown in Figure 1. These three phases are briefly described below.

1.4.1 Planning

Prior to the verification testing of any mercury amalgam removal technology, the testing program must be properly planned. The planning phase involves a number of characterization activities culminating in the preparation of a site specific Test Plan.

The main activities involved in the planning stage are as follows:

- identifying the individuals or organizations that will be involved in the testing, and the responsibilities of all parties;
- identifying the general and specific objectives of the testing;
- identifying a suitable test site;

- designing the experimental program for the testing, including sampling, analysis and scheduling;
- determining the quality assurance and quality control program;
- determining how data will be handled and verified; and,
- preparing a site specific Test Plan.

1.4.2 Verification Testing

This phase includes the actual verification testing activities, using the activities specified in the Test Plan. The mercury amalgam removal technology will be operated in order to assess its ability to meet the objectives identified in the planning stage.

1.4.3 Data Assessment and Reporting

This last phase includes all data analysis and data verification steps, as well as Verification Report preparation**.**

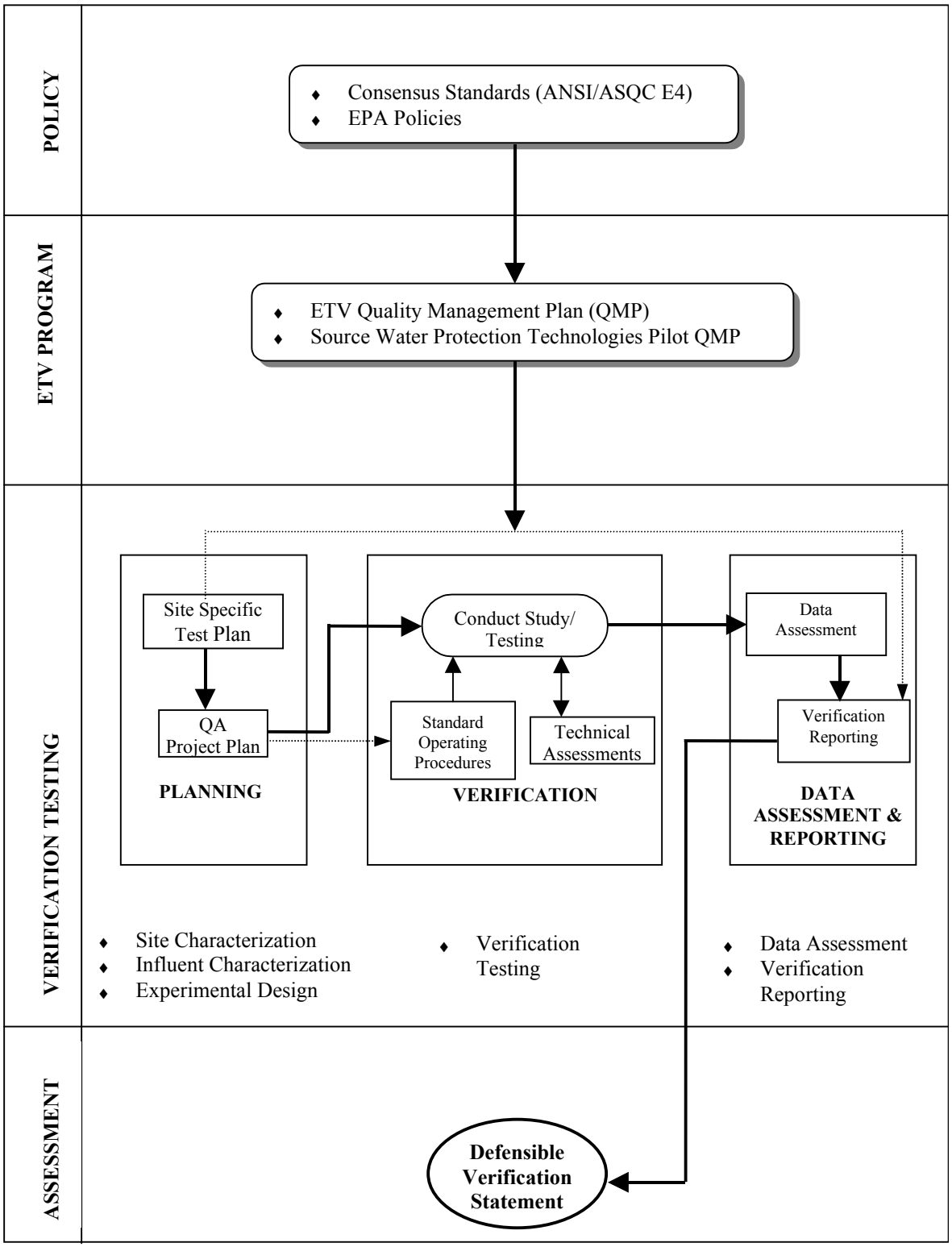
1.5 Policies and Program Specifications and Guidelines

Figure 1 shows the relationship of the verification testing process to USEPA policies and consensus standards such as ANSI/ASQC E4[(1)] and quality management plans (QMPs).

The ETV QMP[(2)] provides specifications and guidelines on test-specific activities. The Source Water Protection Technologies Pilot QMP[(3)] addresses the quality systems for testing activities.

The verification testing process shall be in accordance with USEPA and ETV policies, specifications and guidelines. Further information on USEPA policies and ETV Program QMPs is available from NSF/USEPA and on the ETV website (http://www.epa.gov/etv).

Figure 1: Verification Testing Process



2.0 RESPONSIBILITIES OF INVOLVED AGENCIES

The testing of mercury amalgam removal technologies will usually involve seven parties, each with responsibilities during verification testing. Agencies that will be involved include the following:

- the vendor of the technology (Vendor);
- the Testing Organization;
- the dental office test site owner (Owner);
- the Verification Organization;
- the USEPA;
- the Technology Panel; and,
- the Stakeholder Advisory Group.

The responsibilities of each party are presented in the following sub-sections.

Due to their approval and permitting powers, regulatory agencies can have an important role to play following verification testing. It is therefore recommended that the appropriate local and state regulatory agencies be advised of proposed testing, and that they be requested to indicate their particular requirements or issues. In turn, the Testing Organization, in conjunction with the Vendor and Owner, should incorporate regulatory agency requirements and issues within the site specific Test Plan as much as possible. In particular, the removal of other amalgam metals (copper, zinc and silver) may be of interest to Publicly Owned Treatment Works.

2.1 Responsibilities of Vendor

The Vendor shall have the following responsibilities:

- initiation of application to ETV for testing;
- selection of the Testing Organization from the Verification Organization qualified list;
- provision of verification testing objectives to be incorporated into the Test Plan;
- selection of the test site;
- provision of any available site data (e.g., representative historical flow and characterization data);
- provision of complete, field-ready equipment and the operations and maintenance (O&M) manual(s) typically provided with the technology (including instructions on installation, start-up, operation and maintenance) for verification testing;
- provision of existing relevant performance data for the technology if it has been tested/operated at other locations;
- provision of logistical and technical support as required;

- provision of assistance to the Testing Organization on the operation and monitoring of the technology during the verification testing on an "as needed" basis; and,
- review and comment on the site-specific Test Plan.

2.2 Responsibilities of Testing Organization

The Testing Organization shall have the following responsibilities:

- preparation of the site specific Test Plan;
- conducting Verification Testing, according to the Test Plan;
- operation and maintenance of the technology in accordance with the Vendor's O&M manual(s);
- controlling access to the area where verification testing is being carried out;
- maintaining safe conditions at the test site for the health and safety of all personnel involved with verification testing;
- scheduling and coordinating all the activities of all verification testing participants, including establishing a communication network and providing logistical and technical support on an "as needed" basis;
- resolve any quality concerns that may be encountered and report all findings to the Verification Organization;
- managing, evaluating, interpreting and reporting on data generated by verification testing;
- evaluation and reporting on the performance of the technology; and,
- if necessary, document changes in plans for testing and analysis, and notify the Verification Organization of any and all such changes before changes are executed.

2.3 Responsibilities of Owner

The Owner shall have the following responsibilities:

- provision of logistical and technical support as may be agreed upon by the Testing Organization, Vendor and Owner;
- provision of assistance during testing as may be agreed upon by the Testing Organization, Vendor and Owner;
- notifying the Testing Organization of any significant changes in dental practices that could affect the volume and composition of wastewater produced at the site; and,
- record the tooth number and number of amalgam surfaces placed and removed, the flushing procedure (chemicals used, volume and frequency) and when chairside traps or vacuum filters are changed.

2.4 Responsibilities of Verification Organization

The Verification Organization shall have the following responsibilities:

- qualification of Testing Organizations;
- provision of a list of qualified Testing Organizations;
- provision of a list of approved analytical laboratories;
- reviewing and commenting on the site specific Test Plan;
- approving the Test Plan in conjunction with reviewers from the Technology Panel;
- carrying out an on-site audit of test procedures;
- reviewing, commenting on and disseminating the Verification Report;
- approving the Verification Report in conjunction with the Stakeholder Advisory Group;
- preparation and dissemination of the Verification Statement; and,
- in some cases act as the testing organization/analytical facility.

2.5 Responsibilities of USEPA

This protocol was developed with financial and quality assurance assistance from the Environmental Technology Verification (ETV) Program, which is overseen by the USEPA. Any Verification Report developed under the ETV Program using this protocol will be subject to the approval of the ORD laboratory director. The USEPA shall have technical and quality assurance review responsibilities throughout the various phases associated with the verification of mercury amalgam removal technologies, including:

- Verification Test Plan development;
- Verification Report development; and
- Verification Statement development.

2.6 Responsibilities of Technology Panel

Representatives from the Technology Panel will assist the Verification Organization in reviewing and commenting on the site specific Test Plan.

2.7 Responsibilities of Stakeholder Advisory Group

The Source Water Protection Stakeholder Advisory Group assists the Verification Organization in the approval of the Verification Report.

3.0 TECHNOLOGY CAPABILITIES AND DESCRIPTION

3.1 Types of Equipment

For the purpose of this Verification Testing program, mercury amalgam removal technologies are defined as pre-engineered, self-contained treatment units that are used for treatment of dental wastewater at individual dental offices. They will provide for the removal of amalgam and mercury, rendering the wastewater suitable for disposal to the sanitary sewer system.

3.2 Performance Objectives

The performance objectives of the technology are provided by the Vendor's stated claim of technology capabilities. In addition to the Vendor's claims, there is a minimum requirement for performance objectives for acceptability to receive a Verification Statement. These are the core treatment performance parameters to be measured for all technologies tested.

The performance evaluation of wastewater treatment technologies is based on the assessment through site specific testing of the following:

- treatment performance, measured by removal efficiencies for specific wastewater quality parameters under a normal range of influent conditions; and,
- O&M performance, measured by a number of quantitative and qualitative O&M indicators, including the use of consumables (i.e., water, chemicals and power), labor requirements, residual generation, ease of operation, and any other factors.

The specific wastewater quality parameters used to assess treatment performance include two categories of parameters.

- The core parameters are wastewater quality parameters used in testing at all sites. The core parameter list is the minimum required for testing purposes.
- Additional parameters may be necessary to verify the Vendor's claims. The Testing Organization shall select additional parameters in conjunction with the Vendor.

The core and additional parameters required for influent and effluent wastewater streams are discussed in Sections 5.3 and 5.5, respectively. O&M parameters are discussed in Section 5.5.

3.3 Acceptability for Testing

The Verification Organization and USEPA are committed to fairness for all technology vendors. However, the Verification Organization and USEPA reserve the right to reject offered mercury

amalgam removal technologies that do not have a demonstrable application for dental office wastewater treatment or which, for technical reasons, cannot be accommodated in the evaluation.

4.0 TEST SITE DESCRIPTION AND ACCEPTANCE

The Vendor may select or work with the Verification Organization to identify the site(s) where verification testing will be performed. The criteria for site selection shall be consistent with the Vendor-specified treatment performance, operating levels and known limitations for the technology.

The wastewater at the test site should challenge the capabilities of the technology with respect to hydraulic and mass loadings, but shall not be beyond the reasonable range of flow and wastewater quality parameters suitable for treatment by the technology as identified by the Vendor.

Configuration of the technology to be tested shall be compatible with the test site with minimal modifications and disturbance to the operation of the dental office, at the discretion of the Vendor and with the approval of the site Owner. The technology shall be installed such that the settlement of suspended solids between operatories (chairs) and the inlet of the of the technology is minimized. The Vendor shall be responsible for leaving the site in a condition acceptable to the Owner.

4.1 Site Suitability

The test site shall be a general dentistry office that places and/or removes amalgams. A site shall be considered suitable by the Verification Organization if it places and/or removes a minimum of forty amalgam surfaces per week and if the line flushing procedure will not affect influent characterization or verification testing (due to volume or chemicals used).

As a minimum, line flushing at a test site shall be carried out twice a week and use approximately one litre of flushing solution (water plus any flushing chemical used) per chair for each flush. Those sites that use sodium hypochlorite-based or ammonium chloride-based chemicals for flushing are not suitable for verification testing due to the effect of these chemicals on mercury solubility. Sites that do not routinely follow these flushing requirements may be considered acceptable if flushing is carried out as specified for a minimum of five weeks prior to influent characterization and throughout the influent characterization and verification testing periods.

Other site suitability factors that should be taken into account when selecting sites are the space availability for the installation of the technology and the effect of the vacuum system in place on the installation of the technology.

4.2 Site Acceptance

The Verification Organization shall be responsible for accepting site locations for Verification Testing. As a minimum, the Vendor shall provide the Verification Organization with the following information to facilitate site acceptance:

- the site location and contact details for the Owner;
- the number of chairs at the dental office;
- the average number of amalgams placed and/or removed per week;
- the line flushing procedure (frequency and volume) and flushing chemical(s) used;
- a schematic of the site showing the location of any existing mercury amalgam removal system and the planned location of the mercury amalgam removal technology to be tested;
- a description of how the mercury amalgam removal technology will be installed, how the influent will be diverted to the technology, and how effluent and residues will be disposed of;
- a schematic showing the technology and sampling equipment elevations to illustrate any changes in vertical flow dynamics from the existing plumbing arrangements at the test site;
- the proposed influent and verification testing monitoring and sampling locations;
- representative historical influent wastewater flow and quality data, if available; and,
- any other relevant or unique features of the test site.

5.0 EXPERIMENTAL DESIGN

5.1 Purpose and Scope of Experimental Design

The preparation of the experimental design is the initial planning stage of verification testing and includes the development of the Test Plan. The purpose of the experimental design is to define the test conditions, performance measures, measurement requirements and data quality indicators for verification testing. The experimental design, which is developed by the Testing Organization, shall reflect the general and specific objectives of the proposed verification testing.

5.2 Test Plan Development

Before verification testing can begin, the Testing Organization shall prepare the site specific Test Plan that presents the specific objectives and tasks for verification testing, the testing experimental design, and the specific procedures to be followed throughout testing. A Test Plan shall be developed for each site where testing occurs.

The Test Plan shall be prepared in conjunction with the Vendor and Owner, and shall be reviewed by representatives from the Technology Panel, by the Verification Organization, and by USEPA prior to implementation. Any substantive comments from the review of the Test Plan shall be addressed in a revised Test Plan to the satisfaction of the Verification Organization and USEPA.

The specific contents of the Test Plan can vary from site to site. As a minimum, the Test Plan shall contain the following components.

- Title Page and Table of Contents
- Test Plan Approval by Project Participants
- Executive Summary
- Objectives and Description of Verification Testing
- Verification Testing Responsibilities
- Technology Description
- Experimental Design
- Field Procedures
- Sampling Procedures
- Analytical Procedures
- Quality Assurance Project Plan
- Data Management, Analysis and Presentation
- Assessments
- References
- Appendices:

- Historical Influent Flow and Wastewater Quality Records
- O&M Manual(s) Supplied by the Vendor
- Environmental, Health and Safety Plan and Material Safety Data Sheets
- Other Documents and Applicable Data

The content requirements for the Test Plan are discussed in more detail in Appendix A.

5.3 Influent Characterization

5.3.1 Introduction

The purpose of influent characterization is to obtain an understanding of the influent wastewater flow and quality characteristics before verification testing of the technology is carried out.

Influent characterization shall be carried out for a minimum five-week period before the technology is installed for testing. Results of this characterization will be used to define system operating conditions and process monitoring requirements. The influent characterization results shall be presented in the Test Plan.

5.3.2 Objectives

The objectives of influent characterization are to:

- determine the daily flow of the wastewater stream to be used for verification testing;
- evaluate the concentrations and daily mass loading of target constituents;
- determine specific operational conditions for the technology to be tested;
- determine process monitoring requirements;
- record and document all influent characterization conditions and results; and,
- identify any required modifications to the Test Plan (e.g., sampling method).

5.3.3 Requirements

The Testing Organization shall prepare a work plan to be included as part of the Test Plan that addresses the following influent characterization requirements:

- the location of sampling;
- the sampling method;
- the frequency of sampling; and,
- the data to be collected.

Guidance on these requirements is presented in the following sub-sections.

Sampling Location

Sampling for quality characterization of the influent shall be carried out at a representative location, at or near the location that the technology will be installed, and should be before the dental wastewater has mixed with any other building wastewater streams. Sampling for influent characterization shall be carried out at a similar elevation to the inlet of the technology to be tested after installation to minimize any difference in solids settlement in the vacuum system before and after verification testing.

For dental offices using wet ring pumps in the vacuum system, sampling will be upstream of the vacuum filter. Samples will be taken after the air water separator upstream of the vacuum pump for dry vacuum pump systems. Any modifications to the sampling location requirements will be detailed in the Test Plan, together with the rationale as to why the sampling location was modified. The location of influent sampling shall be identified in the Test Plan.

New chairside traps will be installed just before the start of the influent characterization program.

Sampling Method

All sampling equipment used shall be non-metallic and free of material that may contain metals. Influent shall be diverted into a container constructed of polypropylene, fluoropolymer, borosilicate glass or other approved material. The minimum volume of the container shall be sufficient to hold the estimated maximum influent wastewater flow over 36 hours (including line flushing). The container shall not interfere with normal operation of the dental office vacuum wastewater disposal system. The container shall be kept under vacuum during collection for wet vacuum pump systems, unless sampling is required to be carried out downstream of the vacuum pump (refer to "Sampling Location" above).

The container shall be used to collect all of the influent over a 24 hour period. In the event that the liquid volume collected in the container is at or above the outlet elevation for the container, the sample shall be considered unsuitable for analysis and discarded. The container shall have an overflow into the existing vacuum system (or floor drain where appropriate) in the event that the wastewater volume exceeds the container volume between sampling events.

The container contents shall be collected every 24 hours when the dental office is operating. The total volume collected shall be transferred within four hours to a settling tank capable of separating the solid fraction from the liquid fraction. The settling tank shall be non-metallic or coated with a material free of metals. The settling tank shall be constructed in such a way to allow settled solids to be collected from the bottom of the tank.

Figure 2: Dental Clinic Liquid-Ring Vacuum Pump System

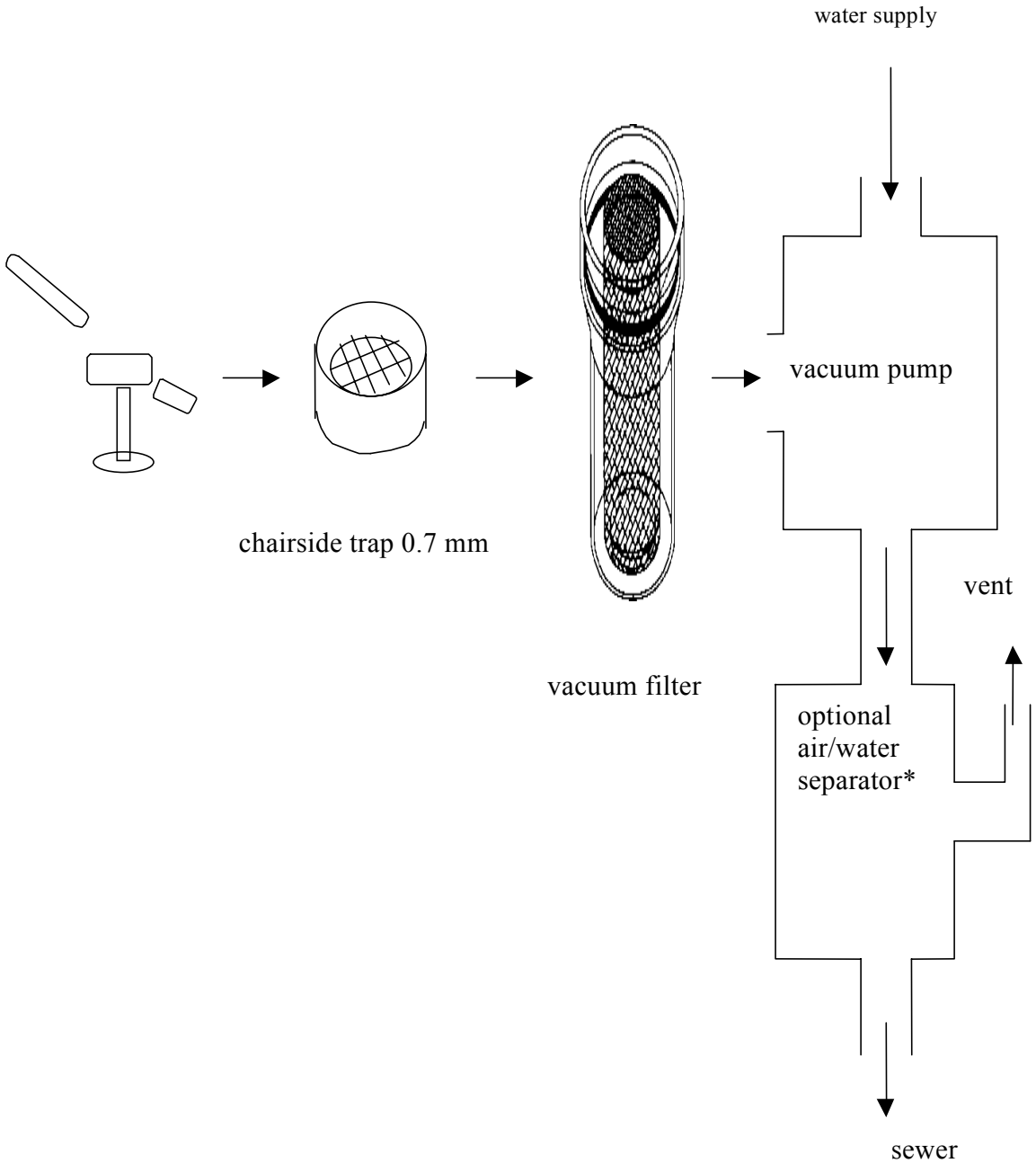
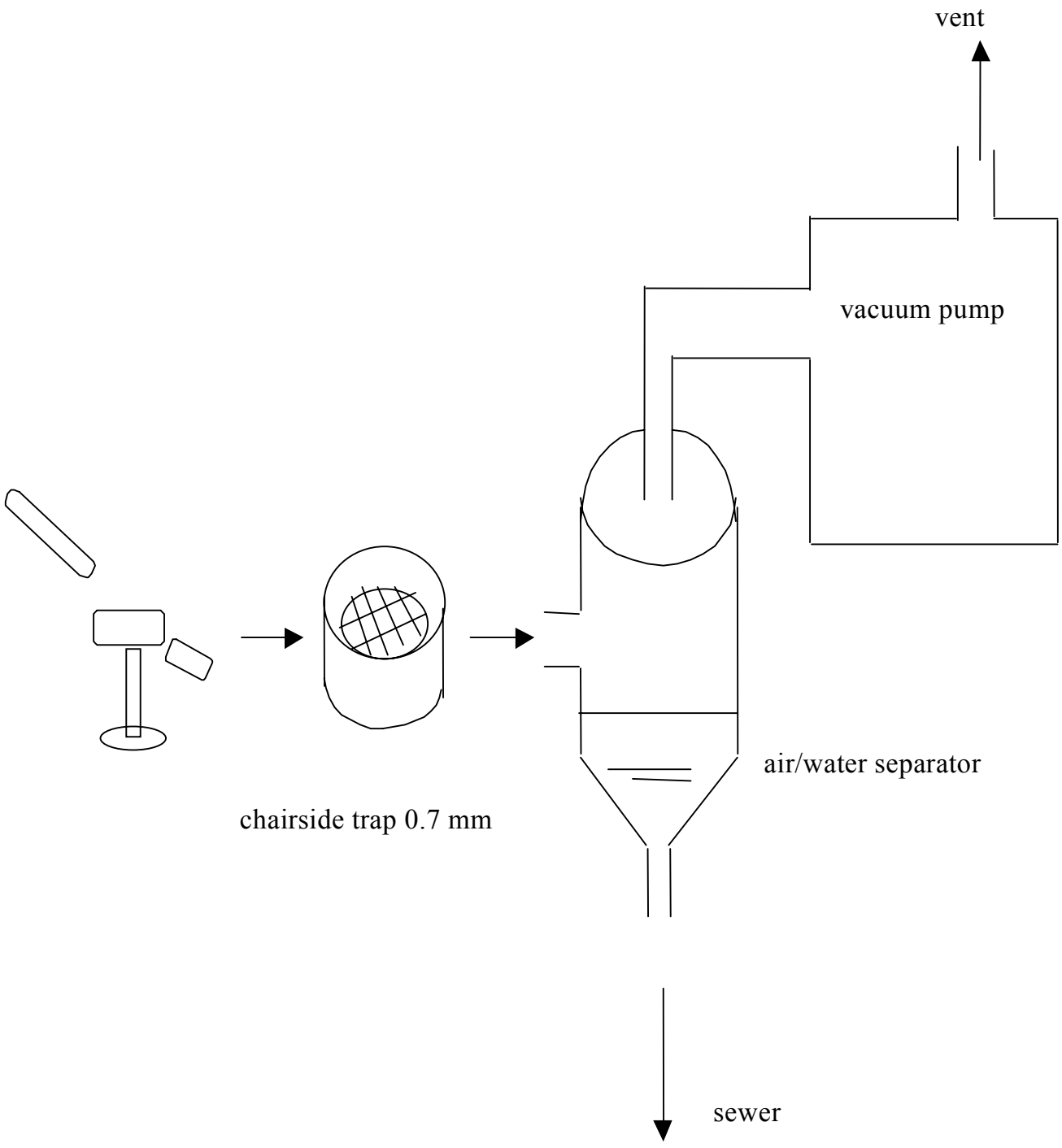


Figure 3: Dental Clinic Turbine (Dry) Vacuum Pump System



The sampling container shall be rinsed with distilled or deionized water containing less than 0.2 μg/L of mercury and the rinse water also transferred to the settling tank. The volume of water used for container rinsing shall be recorded and taken into account when analyzing the samples.

The sample and rinse water shall be settled for a minimum of eight hours and maximum of 16 hours. The total solids settled shall be collected for analysis. The supernatant will be decanted and mixed sufficiently to ensure suspension of any remaining solids before it is sub-sampled for analysis. Refer to Table 1 for the solid and liquid fraction analysis required.

The method used for total sample collection, sample settlement, sampling of the solid fraction and subsampling of the liquid fraction shall be described in the Test Plan. The methods employed for sample collection, preservation and storage shall comply with USEPA Methods[4] or Standard Methods[5]. Any modifications to USEPA or Standard Methods shall be detailed, together with the rationale as to why the method was modified. Details of sampling methods and storage and preservation techniques shall be documented in the Test Plan.

Thorough cleaning of the sampling container(s) and any fittings is required at the end of influent characterization. Cleaning will involve scraping to remove any solids adhered to the surface of the container or fittings, rinsing with mercury-free water and a final 1% nitric acid rinse using mercury-free water. Any solids collected during cleaning and all water used during cleaning shall be settled and sampled as for influent characterization samples for analysis. The method used to clean the sampling container shall be described in the Test Plan.

Sampling Frequency and Data Collection

A minimum of 25 samples shall be collected over a minimum five-week period. Table 1 presents the core influent parameters to be measured for the solids collected and liquid sub-sample. The influent shall be characterized for all core performance parameters. There may be a need to monitor additional parameters, in line with Vendor's claims (e.g., copper, zinc, silver). These parameters shall be selected by the Testing Organization in agreement with the Vendor.

Industry standard procedures (USEPA Methods[4] or Standard Methods[5]) shall be employed for sample analysis. Any modifications to USEPA or Standard Methods will be detailed, together with the rationale as to why the method was modified. All samples shall be analyzed in triplicate for mercury. For solid mercury analysis, the method used for digestion should be validated using a standard sample. The source of the standard sample will be specified by the verification organization. Details of analytical methods and field and laboratory QA/QC procedures shall be documented in the Test Plan. The laboratory to be used for analysis shall be approved by the Verification Organization.

A record of the tooth number and number of amalgam surfaces placed and removed, the flushing procedure (chemicals used, volume and frequency) and when chairside traps are changed will be

recorded for the period of influent characterization. The procedure used to record and report this information shall be provided in the Test Plan.

In some cases, existing data may be available such that the Testing Agency can forego some of the influent quality characterization as part of verification testing. Such data would include existing influent characterization data for the test site. In the event that existing data are employed, the Testing Agency must present details of the data collection procedures, including monitoring and sampling methods, quality assurance (QA) and quality control (QC), and data analysis and reporting procedures in the Test Plan for approval by the Verification Organization. A discussion of QA and QC requirements is provided in Section 6.

Table 1: Summary of Influent Analytical Requirements

Parameter	Solid Fraction[1]	Liquid Fraction[1]
Core parameters		
Volume (liters)[2]		√
pH		√
Approximate volume of solids (particle(s)) (mL)[3]	√	
Solid (Particle) mercury (mg)[4]	√	
Total mercury (mg/L)[5]		√
Soluble mercury (mg/L)[5]		√
Supplemental parameters[6]	√	√

Note:

1. Minimum of 25 samples, each a complete sample of all the waste generated over a 24 hour period.
2. Total volume of wastewater and rinse water recorded separately.
3. Volume estimated after as much as possible of the liquid fraction has been removed.
4. Digestion required before analysis.
5. Analysis carried out on a representative sub-sample of the liquid fraction.
6. To be determined by the Testing Organization in agreement with the Vendor.

5.4 Commissioning

5.4.1 Introduction

The wastewater treatment technology to be tested shall be commissioned in accordance with Vendor instructions provided in the O&M manual(s), which shall be incorporated into and attached to the Test Plan. The Vendor shall indicate a length of time required for commissioning. The Vendor shall specify the factors that may affect commissioning and modifications or procedures that may be required to achieve operation. This information shall also be incorporated into the Test Plan. The commissioning conditions and observations shall be presented in the final Verification Testing report.

5.4.2 Objectives

The objectives of the commissioning task are to:

- commission the mercury amalgam removal technology in accordance with the Vendor's O&M manual(s);
- make modifications as needed to achieve operation; and,
- record and document all commissioning conditions and observations.

5.4.3 Requirements

The Testing Organization shall prepare a work plan to be included as a part of the Test Plan that addresses the following commissioning requirements:

- The Testing Organization shall commission the mercury amalgam removal technology in accordance with the Vendor's O&M manuals(s).
- The mercury amalgam removal technology installed shall be clean and free of any mercury residuals.
- The Testing Organization shall conduct commissioning for the period specified by the Vendor. Any modifications needed to ensure operation of the technology shall be identified.
- The Testing Organization shall document conditions and observations made throughout the commissioning period. These details are to be presented in the Verification Report.

5.5 Verification Testing

5.5.1 Introduction

The treatment performance of the technology under field conditions shall be evaluated and documented during verification testing. This shall be accomplished by sampling effluent generated by the technology and sampling residuals retained by the technology. O&M conditions shall also be monitored and documented. Verification testing conditions, observations and results shall be presented in the Verification Report.

5.5.2 Objectives

The objectives of verification testing are to:

- evaluate the treatment performance of the technology, relative to removal of specific parameters, operating under Vendor-specified conditions;
- evaluate the technology O&M conditions; and,

- record and document test conditions, observations and results.

5.5.3 Requirements

The Testing Organization shall prepare a work plan to be included as part of the Test Plan that addresses the following verification testing requirements:

- the location of sampling;
- the effluent sampling method;
- the residuals sampling method;
- the frequency of sampling; and,
- the data to be collected

Sampling Locations

Sampling for quality characterization of the effluent shall be carried out at a representative location at or near the outlet of the technology, and before the dental wastewater has mixed with any other building wastewater streams. Sampling shall be carried out at a similar elevation to that for influent characterization to minimize any difference in solids settlement in the vacuum system before and after verification testing. The location of effluent sampling shall be clearly identified in the Test Plan.

New chairside traps shall be installed just before the start of verification testing.

Effluent Sampling Method

All sampling equipment used shall be non-metallic and free of material that may contain metals. Effluent shall be diverted into a container constructed of polypropylene, fluoropolymer, borosilicate glass or other approved material. The minimum volume of the container shall be sufficient to hold the estimated maximum effluent wastewater flow over 36 hours (including line flushing). The container shall not interfere with normal operation of the dental office vacuum wastewater disposal system. The container shall be kept under vacuum during collection for wet vacuum pump systems, unless sampling is required to be carried out downstream of the vacuum pump.

The container shall be used to collect all of the effluent over a 24 hour period. In the event that the liquid volume collected in the container is at or above the outlet elevation for the container, the sample shall be considered unsuitable for analysis and discarded. The container will have an overflow into the existing vacuum system (or floor drain where appropriate) in the event that the wastewater volume exceeds the container volume between sampling events.

The container contents shall be collected every 24 hours when the dental office is operating. The total volume collected shall be transferred within four hours to a settling tank capable of separating the solid fraction from the liquid fraction. The settling tank shall be non-metallic or coated with a material free of metals. The settling tank will be constructed in such a way to allow settled solids to be collected from the bottom of the tank.

The sampling container will be rinsed with distilled or deionized water containing less than 0.2 µg/L of mercury and the rinse water also transferred to the settling tank. The volume of water used for container rinsing will be recorded and taken into account when analyzing the samples.

The sample and rinse water shall be settled for a minimum of eight hours and maximum of 16 hours. The total solids settled shall be collected for analysis. The supernatant shall be decanted and mixed sufficiently to ensure suspension of any remaining solids before it is sub-sampled for analysis. Refer to Table 2 for the solid and liquid fraction analysis required.

Table 2: Summary of Effluent and Residual Analytical Requirements

Parameter	Effluent[1,2]		Residuals	
	Solid Fraction	Liquid Fraction	Solid Fraction	Liquid Fraction
Core parameters				
Volume (litres)[3]		√		√
pH		√		√
Approximate volume of solids (particle(s)) (mL)[4]	√		√	
Solid (particle) mercury (mg)[5]	√		√	
Total mercury (mg/L)[6]		√		√
Soluble mercury (mg/L)[6]		√		√
TCLP[7]			√	
Supplemental parameters[8]	√	√	√	√

Note:

1. Minimum of 25 samples, except for TCLP analysis.
2. Collect all of the effluent over a 24 hour period.
3. Total volume of wastewater and rinse water recorded separately.
4. Volume estimated after as much as possible of the liquid fraction has been removed.
5. Digestion required before analysis.
6. Analysis carried out on a representative sample of the liquid fraction.
7. Toxicity characteristic leaching potential, as per USEPA method SW 846 1311. Required for minimum of one sample.
8. To be determined by the Testing Organization in agreement with the Vendor.

The method used for total sample collection, sample settlement, sampling of the solid fraction and subsampling of the liquid fraction shall be described in the Test Plan. The methods employed for sample collection, preservation and storage shall comply with USEPA Methods(4) or Standard Methods(5). Any modifications to USEPA or Standard Methods shall be detailed,

together with the rationale as to why the method was modified. Details of sampling methods and storage and preservation techniques shall be documented in the Test Plan.

Thorough cleaning of the sampling container(s) and any fittings is required at the end of verification testing. Cleaning shall involve scraping to remove any solids adhered to the surface of the container or fittings, rinsing with mercury-free water and a final 1% nitric acid rinse using mercury-free water. Any solids collected during cleaning and all water used during cleaning shall be settled and sampled for analysis, as for influent characterization samples. The method used to clean the sampling container shall be described in the Test Plan.

Residuals Sampling Method

All sampling equipment used should be non-metallic and free of material that may contain metals. Residuals retained by the technology shall be sampled once a week, unless the Vendor indicates otherwise. For those technologies where it is not feasible to regularly collect residuals samples for some or all of the equipment, e.g., cartridge filters, the residuals shall be sampled at the end of verification testing or when the equipment containing the residuals is replaced, whichever occurs first.

All residual solids shall be collected. If liquids are present with the residual solids, the residuals will be settled as in Section 5.5.3 above to separate the liquids from the solids. The methods used for collecting residual samples and processing shall be described in the Test Plan.

USEPA Methods[4] or Standard Methods[5] shall be employed for sample collection, preservation and storage. Any modifications to USEPA or Standard Methods shall be detailed, together with the rationale as to why the method was modified. Details of sampling methods and storage and preservation techniques shall be documented in the Test Plan.

Sampling Frequency and Data Collection

A minimum of 25 effluent samples shall be collected over a minimum five-week period. Table 2 presents the core effluent and residual parameters to be measured. The effluent and residual samples shall be characterized for all core performance parameters. There may be a need to monitor additional parameters, in line with Vendor's claims (e.g., copper, zinc, silver). These parameters shall be selected by the Testing Organization in agreement with the Vendor.

Industry standard procedures (USEPA Methods[4] or Standard Methods[5]) shall be employed for sample analysis. Any modifications to USEPA or Standard Methods shall be detailed, together with the rationale as to why the method was modified. All samples shall be analyzed in triplicate for mercury. For solid mercury analysis, the method used for digestion should be validated using a standard sample. Details of analytical methods and field and laboratory QA/QC procedures

shall be documented in the Test Plan. The laboratory to be used for analysis must be approved by the Verification Organization.

A record of the tooth number and number of amalgam surfaces placed and removed, the flushing procedure (chemicals used, volume and frequency) and when chairside traps are changed shall be recorded for the period of verification testing. The procedure used to record and report this information shall be provided in the Test Plan.

In some cases, existing data may be available such that the Testing Agency can forego some of the quality characterization as part of verification testing. Such data include test data from previous studies for the technology. In the event that existing data are to be employed, the Testing Agency must present details of the data collection procedures, including monitoring and sampling methods, quality assurance (QA) and quality control (QC), and data analysis and reporting procedures in the Test Plan for approval by the Verification Organization. A discussion of QA and QC requirements is provided in Section 6.

Operations and Maintenance Performance

Both quantitative and qualitative performance indicators shall be evaluated to assess test equipment O&M performance. The Testing Organization shall prepare O&M performance indicators in conjunction with the Vendor.

Qualitative O&M performance indicators shall include, but are not limited to, the following:

- observations regarding ease of operation;
- observations regarding the effect of the technology, if any, on the operation of the vacuum system;
- a log of any operating problems recorded during testing;
- quality of the O&M manual (e.g., actual O&M compared to that indicated in the manual, clarity of instructions); and,
- observations regarding labor requirements.

Quantitative O&M performance indicators shall include the following:

- duration (in hours) of typical clean-out operations (if any);
- frequency and duration (in hours) of any preventative or breakdown maintenance activities;
- electrical consumption (if any) for all unit processes, measured as kilowatt hours consumed and the number of hours the equipment was operational, where possible;
- chemical consumption (if any) for all unit processes, measured as kg per day; and,
- records of any other consumables used by the technology over the test period.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

QA activities and procedures for the verification testing shall be provided in a Quality Assurance Project Plan (QAPP). The QAPP shall provide information on data review, validation, and verification requirements, including the criteria used to review and validate data, validation and verification methods, and reconciliation with data quality objectives.

The QAPP shall apply to all organizations involved in verification testing, including analytical laboratories. The Testing Organization shall have the primary day-to-day responsibility for ensuring that all individuals involved in verification testing comply with QA/QC procedures. The Verification Organization Manager of Corporate QA and Safety or a designee shall monitor and audit subcontracting laboratories in accordance with their corporate Quality Assurance Manual, and, for Verification Testing activities conducted under the ETV Source Water Protection Pilot, the Source Water Protection Pilot Quality Management Plan. A copy of the Test Plan, including the QAPP, shall be forwarded to all parties involved with Verification Testing, including analytical laboratories.

Reference shall be made to USEPA's Guidance for Quality Assurance Project Plans[6] and Guidance for the Data Quality Objectives Process[7].

6.1 Verification of Test Data

All performance measurements carried out should be verifiable by a statistical analysis of the data. As part of the assessment of data quality, six data quality indicators (DQIs) can be used to interpret the degree of acceptability or utility of the data. The QAPP shall include a protocol for assessing the following DQIs (refer to Glossary of Terms for definitions), and acceptable limits and criteria for each of these indicators.

The DQIs include the following:

- precision;
- bias;
- accuracy;
- representativeness;
- comparability; and,
- completeness.

The Testing Organization shall determine acceptable values or qualitative descriptors for all DQIs in advance of verification testing as part of the experimental design. The assessment of data quality will require specific field and laboratory procedures to determine the data quality indicators. All details of DQI selection and values shall be documented in the QAPP.

6.2 Management

The QAPP shall include documentation on the management of the project, the project history and objectives, and the responsibilities of each of the participants. The purpose of this element is to ensure that the project approach and goals are clearly stated and understood by all participants. This area shall include a list of individuals involved in the project, their roles and responsibilities, a concise definition of the purpose of the study, a project schedule including a task chart, documentation of the data quality objectives, special training and certification requirements, and a complete list of required documentation for the study.

6.3 Measurement and Data Acquisition

The QA discussion shall include specific information on all aspects of the experimental design including a detailed description of each component. Specific requirements in the area of measurement and data acquisition are described below.

- A schedule of project sampling, analysis, and data peer-review activities shall be provided.
- Any assumptions made in the design of the experiment and all procedures for locating and selecting environmental samples shall be documented.
- Any non-standard sampling or measurement techniques and equipment used to assess the potential impact on the representativeness of the data generated shall be validated.
- The requirements for sample handling and custody in the field, laboratory and in transport shall be described. The description shall include examples of sample labels, custody forms, and sample custody logs.
- Analytical methods, equipment and the specific performance for each method shall be documented. Reference may be made to USEPA Methods[4] or Standard Methods[5].
- Required measurement quality control checks for both the field and the laboratory shall be identified. Information presented shall include the frequency of each type of QC check and references for the procedures used to calculate each of the QC statistics.
- All equipment calibration requirements including standards for calibration, and calibration methods, shall be identified.
- Any types of data needed for project implementation obtained from non-measurement sources shall be identified, including definition of acceptance criteria and discussion on the limitations on the use of any such data.

6.4 Assessment

The QAPP shall include a detailed section on the methods to be used to assess the effectiveness of the implementation of the QA/QC activities. Specifically, this section shall provide information on the types of assessments to be completed, description of response actions, and details on the types of reports to management to be completed.

The number, frequency and type of assessment activities to be used in the project shall be specified including a definition of the scope of the authority of the Testing Organization assessors and when they are authorized to act, how responses to non-conforming conditions will be addressed, and the individuals responsible for implementation of the response action.

6.5 Corrective Actions

Each Test Plan shall include a corrective action plan. This plan shall include the predetermined acceptance limits, the corrective action to be initiated whenever such acceptance criteria are not met, and the names of the individuals responsible for implementation. Routine corrective action may result from common monitoring activities, such as:

- Performance evaluation audits
- Technical systems audits

Ultimately, responsibility for project quality assurance/quality control (QA/QC) during implementation of this protocol rests with the Verification Organization, specifically the Verification Organization Project Manager, with appropriate input from the Verification Organization QA/QC Manager. However, immediate QA/QC for individual tasks (e.g. sample collection, handling, preparation, and analysis) rests with the individuals and organization performing the task at hand, as described in this chapter and throughout the protocol. The Verification Organization Project Manager will coordinate oversight and/or audits of these tasks with the Testing Organization Project Manager to ensure that the Test Plan is being executed as written, and that nonconformances are appropriately reported and documented.

Corrective action shall be taken whenever a nonconformance with the Test Plan occurs. Nonconformances can occur within the realm of sampling procedures, sample receipt, sample storage, sample analysis, data reporting, and computations.

7.0 DATA MANAGEMENT, ANALYSIS AND PRESENTATION

Data that will be generated by Verification Testing include, but are not limited to, flow data, influent and effluent wastewater quality data, residuals data, treatment performance of the technology under specific operating conditions, and O&M parameters. These data will be managed, analyzed and presented as described in the following sub-sections.

7.1 Data Management

Verification testing will generate a significant amount of data. The Test Plan shall present the procedures to be followed for data collection, recording, and storage. Data may be collected by manual and/or electronic means. The Testing Organization shall determine the most appropriate data collection format as part of the experimental design.

Each sampling event shall be assigned a specific identification number that will be tied to all data from that sampling event through each step of data entry and analysis. The data from a sampling event shall include the wastewater flow and quality data as well as operational settings and conditions, sampling locations, day, time, personnel involved, etc. The identification numbers shall track samples delivered to analytical laboratories that have been approved by the Verification Organization, along with the results in the laboratory reports. Laboratory reports shall be received and reviewed by the Testing Organization. These data will be entered into the data spreadsheets, cross-checked, and verified in the same manner as previously discussed.

The QA/QC procedures for managing, reviewing and verifying data shall be presented in the QAPP contained in the Test Plan. The means to obtain, record, verify and store data obtained manually and electronically (data loggers, computers, etc.) shall be discussed in the QAPP. Refer to Section 6 for further QA/QC information.

7.1.1 Manual Data Collection

For manual data recording, the Testing Organization shall record all data and calculations by hand in laboratory notebooks with carbon copies. Daily measurements and other information shall be recorded on specially prepared data log sheets, as appropriate. The original notebooks shall be stored at the test site and the carbon copy sheets shall be forwarded to the Testing Organization project manager at least once per week. Logs shall include a description of the system, test runs, dates and times, any problems or issues, corrective actions (as required), experimental calculations, and other pertinent items.

7.1.2 Electronic Data Collection

Data in electronic format shall be included in commercially available programs for word processing, spreadsheet or database processing, or commercial software developed especially for data collection and processing on a specific hardware instrument or piece of equipment. A database for the project shall be set up in the form of custom-designed spreadsheets. The spreadsheets shall be capable of storing and manipulating the wastewater quality data from each sampling event, along with the corresponding operational parameters, sampling location, day and time, etc.

All manually entered data from laboratory notebooks and data log sheets shall be entered into the appropriate spreadsheet on a weekly basis as a minimum. All recorded calculations shall be verified by the Testing Organization during entry into the spreadsheet. Following data entry, the spreadsheet shall be printed out and the printout shall be verified against the handwritten data sheet, preferably by Testing Organization personnel not involved with the data entry. Any corrections shall be noted on the hardcopies of the data sheets and corrected on the electronic copy, and then a corrected version of the spreadsheet shall be printed out. The printouts shall be initialled and dated by the Testing Organization personnel performing the data verification.

The printouts shall be stored onsite in chronological order in a project binder. Copies of the verified and corrected printouts shall be forwarded to the Testing Organization project manager at least once per week. At least two electronic backups of the data spreadsheets shall be kept (e.g., one copy on computer hard drive and one copy on disk).

If formulae and functions are written into the spreadsheets for data manipulation and calculations, then these formulae and functions shall be verified periodically to ensure that they are being used and entered correctly. The spreadsheets shall undergo a monthly audit, as a minimum, by the Testing Organization to ensure the formulae and functions are being used and are entered correctly. Verification may involve reviewing sample formulae and making sure the correct cells are referenced, the formula is entered correctly (e.g., parenthesis and operations are correct), as well as performing random hand calculations and comparing the results to those calculated by the spreadsheet program. The spreadsheet audits shall be recorded in a log with the date, reviewer initials, name and timeframe of data set inspected for identification, audit findings, and any modifications made to the spreadsheets.

7.2 Data Analysis and Presentation

All results, including statistical analysis, will be provided in the Verification Report. Any data not included in statistical analysis will also be reported, together with the rationale as to why it was not included in the analysis.

The data obtained during influent characterization and verification testing shall be statistically analyzed, reduced, and presented in tables, graphs and/or charts in a clear and concise manner. Raw data shall be included as an appendix to the Verification Report. The statistical methods and any statistical programs used will be described in the Verification Report.

It must be possible to compare the results as presented to the original raw data and test conditions that the results were obtained under. The QAPP contained in the Test Plan shall address this requirement.

A detailed discussion of the results shall accompany the tables, graphs and/or charts and shall be presented in the Verification Report (see Section 7.3). The Testing Organization shall provide and discuss conclusions drawn from the test results.

Guidance on analysis and presentation for specific data is presented in the following sub-sections.

7.2.1 Flow Data

Flow data obtained during the influent characterization and verification testing periods shall be analyzed and presented as follows:

- a graph showing daily flows; the date, time, and sample number corresponding to the data presented shall be shown on the graph, as applicable; and,
- a table showing average, maximum and minimum daily flow, and 95% confidence interval.

7.2.2 Treatment Performance Quality Data

Valid wastewater quality data obtained during the influent characterization and verification testing periods shall be analyzed and presented as follows:

- graphs showing the daily influent sampling results obtained for all core and additional parameters;
- tables showing the average, maximum and minimum influent concentration for the sampling events and the 95% confidence interval for all core and additional parameters;
- graphs showing the daily effluent sampling results obtained for all core and additional parameters;
- tables showing the average, maximum and minimum effluent concentration for the sampling events and the 95% confidence interval for all core and additional parameters;
- table showing the average and the 95% confidence interval for the mass of mercury in the residual stream (where there is sufficient data);
- tables showing the average removal efficiency by the technology and the 95% confidence limit for total mercury, soluble mercury and any additional parameters measured; and,
- date, time, and sample number corresponding to the data presented shall be shown on the graphs, as applicable.

7.2.3 Operations and Maintenance Parameters

Results of monitoring operations and maintenance parameters (see Section 5.5.3) during verification testing shall be presented in tables or other appropriate format and thoroughly discussed in the final Verification Report.

All O&M performance data shall be reported in the Verification Report as an average value for the duration of verification testing.

7.2.4 Equations

Equations to be used in the data analysis are provided below.

Removal Efficiency (as percent)

Example of removal technology installed in a "dry vacuum" system, or installed in a "wet vacuum" system.

$$= \frac{\text{(mg Hg captured in removal technology)}}{\text{(mg Hg capt'ed in rem. tech. + mg Hg in samples* taken after removal technology)}} \times 100$$

* Samples are settled prior to analysis, resulting in a liquid component and a solids component. Therefore, data for each sample will include a mass for the liquid component (mg/l X liters) and a mass for the solids component.

Sample Mean (Average)

$$y_{bar} = \Sigma v / n$$

Where:

y_{bar} is the sample mean

Σv is the sum of the sample values

n is the number of samples

Standard Deviation

$$s = (\Sigma (y - y_{bar})^2 / n)^{1/2}$$

Where:

s is the sample standard deviation

y is an individual sample value

y_{bar} is the sample mean

95% Confidence Interval

$$= y_{bar} \pm t_{\alpha/2} (s / n^{1/2})$$

Where:

y_{bar} is the sample mean

s is the sample standard deviation

n is the number of samples

$t_{\alpha/2}$ is the Student's t-distribution with n-1 degrees of freedom, with $\alpha/2=0.025$

and

$t_{\alpha/2}$ = 2.068 for n=25

Refer to statistical references for other values.

7.3 Verification Report

The Verification Report shall be a comprehensive document containing all raw and analyzed data, all QA/QC data sheets, a description of all types of data collected, a detailed description of the testing procedure and methods, results and QA/QC results.

A recommended Table of Contents for the Verification Report is as follows.

- Preface
- Glossary
- Acknowledgements
- Executive Summary
- Introduction and Background
- Procedures and Methods Used In Testing (summarizing essential information from the Test Plan)
- Results and Discussion
- Limitations
- Conclusions
- Recommendations
- References
- Appendices (including raw data)

The exact details of the Verification report shall be at the discretion of the Testing Organization.

8.0 ENVIRONMENTAL, HEALTH AND SAFETY PLAN

The Testing Organization shall strictly follow and enforce environmental, health and safety measures during influent characterization and verification testing. An environmental, health and safety plan shall be included in the Test Plan. The plan shall identify all environmental concerns and potential hazards associated with the testing and the test location, and the required measures to prevent exposure to these hazards. The Testing Organization shall be responsible for informing all personnel at the test site, including site employees not associated with the testing program, of the potential hazards at the test site and the safety measures to be employed.

Environmental, health and safety procedures in the plan shall address the following, as applicable:

- biological, chemical and electrical hazards;
- storage, handling and disposal of hazardous chemicals and biological materials (including wastewater samples);
- material safety data sheets (MSDS);
- conformance with applicable electrical and plumbing codes at the test site;
- ventilation equipment for trailers or housing equipment if gases are present that may pose a safety hazard;
- confined space entry hazards;
- any other specific safety or environmental issues associated with the technology or a specific piece of equipment;
- emergency contact details for the nearest hospital (provide directions), local fire department, the Site Owner, and the Testing Organization project manager; and,
- any permitting requirements for disposal of residues.

A copy of the Test Plan's environmental, health and safety procedures, including all MSDS, shall be maintained and readily accessible at the test site. A one-page summary of emergency contact details shall be placed inside a clear plastic cover and kept in a clearly visible place in the vicinity of the technology test unit.

9.0 REFERENCES

(1) ANSI/ASQC: *Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs (E4)*, 1994.

(2) United States Environmental Protection Agency: *Environmental Technology Verification Program - Quality and Management Plan for the Pilot Period (1995 – 2000)*, USEPA/600/R-98/064, 1998. Office of Research and Development, Cincinnati, Ohio.

(3) NSF International, *Environmental Technology Verification – Source Water Protection Technologies Pilot Quality Management Plan*, 2000. Ann Arbor, Michigan.

(4) United States Environmental Protection Agency: *Methods and Guidance for Analysis of Water*, EPA 821-C-99-008, 1999. Office of Water, Washington, DC.

(5) APHA, AWWA, and WEF: *Standard Methods for the Examination of Water and Wastewater,* 1998. Washington, DC.

(6) United States Environmental Protection Agency: *USEPA Guidance for Quality Assurance Project Plans, USEPA QA/G-5*, USEPA/600/R-98-018, 1998. Office of Research and Development, Washington, DC.

(7) United States Environmental Protection Agency, *Guidance for the Data Quality Objectives Process, USEPA QA/G-4*, USEPA/600/R-96-055, 1996. Office of Research and Development, Washington, DC.

APPENDIX A
TEST PLAN OUTLINE AND CONTENT REQUIREMENTS

1.0 OUTLINE OF THE TEST PLAN

The Testing Organization shall prepare the site-specific Test Plan. The specific contents of the Test Plan may vary from site to site. As a minimum, the Test Plan must contain the following components.

- Title Page and Table of Contents
- Test Plan Approval by Project Participants
- Executive Summary
- Objectives and Description of Verification Testing
- Verification Testing Responsibilities
- Technology Description
- Experimental Design
- Field Procedures
- Sampling Procedures
- Analytical Procedures
- Quality Assurance Project Plan
- Data Management, Analysis and Presentation
- Assessments
- References
- Appendices:
  - historical influent flow and wastewater quality records (where this data is to be used with the approval of the Verification Organization)
  - effluent and residuals data from previous tests (where this data is to be used, with the approval of the Verification Organization)
  - O&M manual(s) supplied by the Vendor
  - Environmental, Health and Safety Plan and Material Safety Data Sheets
  - other documents and applicable data

A brief description of selected Test Plan requirements is presented in the following sections.

2.0 OBJECTIVES AND DESCRIPTION OF VERIFICATION TESTING

This section of the Test Plan shall include the following:

- the objectives (including Vendor claims) and an overview of the testing to be performed;
- a description of the test site, flushing procedure used and the number of amalgams placed and/or removed per week;

- a map showing the location of the test site;
- the site name and address, including street number/fire number, state, county, and telephone number;
- the name and address of the site owner;
- the number of chairs dedicated to hygiene only and the number of chairs for general dentistry at the dental office;
- a description of any current method(s) of wastewater handling/treatment at the test site;
- a summary of any existing data on the wastewater flowrate and strength;
- a description of how the mercury amalgam removal technology will be installed, how the influent will be diverted to the technology, and what will be done with effluent and residues generated;
- a site plan/layout showing the configuration of the technology to be tested and the sampling equipment, including elevations of the technology and sampling equipment; and
- approximate timeframes for influent characterization, system installation and commissioning, and the verification testing period.

3.0 VERIFICATION TESTING RESPONSIBILITIES

Key staff in the Testing Organization and other organizations involved in the verification testing shall be identified. A description of the responsibilities for all parties shall be provided. Contact details for key staff within each party shall be provided.

4.0 TECHNOLOGY DESCRIPTION

The Test Plan shall include the following information on the wastewater treatment technology to be tested:

- a simple schematic of the technology, showing all major components;
- a brief introduction and discussion of the engineering and scientific concepts (process kinetics and hydraulics) on which the mercury amalgam removal technology is based;
- a description of the mercury amalgam removal technology, including the following:
  - specifications;
  - full description of each unit process, along with relevant photographic perspectives or schematics;
  - equipment capacity and dimensions;
  - physical construction/components of the equipment, including materials of construction;
  - general environmental requirements and limitations;
  - required consumables; and,
  - weight, transportability, and power requirements;

- a description of any scaling up or down of the test equipment compared to a typical full-scale installation, and the impact this may have on treatment performance;
- a description of the applications of the technology, the flow and load capacity, and the expected removal capabilities of the technology;
- an estimate of the O&M requirements, including chemicals and materials requirements (specifying type and purpose), power requirements and labor requirements;
- instructions on installation, start-up, operation, routine maintenance, and troubleshooting;
- a description of the biological, physical and chemical nature of residues generated by the technology, and rates of waste produced (e.g., concentration and volume of residues, material replacement frequency);
- requirements and/or recommendations for residuals handling;
- identification of any special licensing requirements associated with the operation of the technology;
- the level of operator skill required to successfully operate the technology; and,
- any noise and/or odor control and housing requirements.

Data plates provided by the Vendor shall be permanent and securely attached to each piece of equipment used for verification testing. The data plate shall be easy to read in English or the language of the intended user, located where it is readily accessible, and contain at least the following information:

- equipment name;
- model number;
- serial number;
- Vendor's name and address;
- electrical requirements (volts, phase, amps, Hertz);
- shipping requirements and special handling precautions;
- warning and caution statements in legible and easily discernible print size; and,
- capacity or output rate (where applicable).

In addition, the Vendor shall provide the O&M manual(s) and all OSHA-required safety devices (where applicable) for the equipment. O&M manuals should include information on installation, start-up, operation, maintenance requirements, component calibration and replacement, troubleshooting, spare parts, optimum operating/environmental conditions, and tolerance to changes in conditions.

5.0 EXPERIMENTAL DESIGN

5.1 Work Plan for Influent Wastewater Characterization

This work plan shall present the plan and procedures for influent characterization. The work plan shall include, but is not restricted to, the following information:

- sampling locations;
- sampling methods;
- sampling frequency and periods;
- the type of sampling equipment (including materials of construction);
- sample preservation and storage methods;
- the type of analysis;
- details on the analytical laboratory carrying out the analysis;
- the method to be used for recording the flushing procedures (frequency, volume and chemicals used), replacement of chairside traps and vacuum filters and number of surfaces placed and/or removed during influent characterization that will enter the influent stream;
- the methods to be used for documenting the results; and,
- the methods to be used to obtain statistically valid sampling results.

5.2 Work Plan for Commissioning

This work plan shall provide the procedures for commissioning of the technology to be tested. The work plan shall include, but is not restricted to, the following information:

- the estimated length of time required for commissioning of the technology;
- the operating methods and monitoring required to ensure effective operation has been achieved, including the limits for each parameter; and,
- the methods for documenting the commissioning and attainment of effective operating conditions.

5.3 Verification Testing Work Plan and Experimental Design

The work plan and experimental design for verification testing shall be provided. This section shall present, but is not limited to, the following details regarding operating the technology:

- the following sampling and analysis details for effluent and residual streams:
  - sampling locations
  - sampling methods
  - sampling frequency and periods
  - type of sampling equipment (including materials of construction)
  - sample preservation and storage
  - type of analysis
  - details on the analytical laboratory carrying out the analysis
- O&M procedures that contain details on the following:

  - type(s) of consumables to be monitored (e.g., chemicals, water, etc.), and the method, frequency and period of monitoring
  - the method, frequency and period of monitoring of power consumption
  - the type(s) of O&M parameters to be monitored, and the method(s) to be used for monitoring O&M labor requirements and other maintenance requirements
  - the method to be used for recording the flushing procedures (frequency, volume and chemicals used), replacement of chairside traps and vacuum filters and number of surfaces placed and/or removed during verification testing
- procedures for managing and reporting the data collected; and,
- the methods used to obtain statistically valid sampling results.

6.0 PROCEDURES

The Test Plan shall identify field, sampling, and analytical procedures to be followed throughout the entire verification testing process. Field procedures may include instructions for sampling, washing sampling containers, calibration of components, etc.

Sampling procedures shall include instructions regarding sample location, type, frequency, method of sample collection, container type, sample preservation, QA/QC samples, holding times, transporting, chain of custody requirements, sample logging, etc. Analytical procedures shall identify the approved measurement methods (USEPA, Standard Methods) for sample analyses, system calibration procedures, etc.

7.0 QUALITY ASSURANCE PROJECT PLAN

A Quality Assurance Project Plan (QAPP) shall be included in the Test Plan, which addresses the following:

- a description of the methodology for using analytical method blanks, the materials used, the frequency of use, the criteria for acceptable method blanks, and the actions to be taken if criteria are not met;
- a description of the methodology for using spiked samples, the materials used, and the frequency of use;
- a description of any specific procedures appropriate to the analysis of performance evaluation samples;
- an outline of the procedure for determining samples to be analyzed in duplicate or triplicate, including the frequency and approximate number;
- a description of the methodology and/or equations used to measure any necessary data quality indicators for performance measurements, which includes precision, bias, accuracy, representativeness, comparability and completeness;
- an outline of the format, content and frequency of Testing Organization self-assessments and their technical systems;

- an outline of the format, content and frequency of assessment reports to the Verification Organization;
- the development of a corrective action plan responding to audit findings;
- the requirement to provide all QA/QC information such as calibrations, blanks and reference samples in an appendix to the report; all raw data shall also be reported in an appendix; and,
- the provision of all data in hardcopy and electronic form in a common spreadsheet or database format.

8.0 DATA MANAGEMENT, ANALYSIS AND PRESENTATION

8.1 Data Management

The Test Plan shall present a plan for data management and handling. The Test Plan shall identify the various types of data that will be generated throughout the verification testing process (e.g., field notes, maintenance forms, laboratory reports, computer spreadsheets, graphs, tables, photographs, and videotapes), and the format of data collection for each (i.e., hard copy or electronic). The Test Plan shall present the methods for verifying the data.

The Testing Organization shall designate a person or group of persons responsible for data handling in the Test Plan. It is recommended that one person be responsible for data management to ensure consistency and correctness, and that another person be responsible for QA/QC for the data set.

8.2 Data Analysis and Presentation

The Test Plan shall detail the methods to be used for analyzing and reducing the data. Details on statistical references/equations shall be provided. A discussion on statistical analysis of the data is provided in Section 7.2 of the protocol.

The Test Plan shall identify the data to be presented and the format of presentation (e.g., tables, graphs).

9.0 ASSESSMENTS

The Test Plan shall identify all internal systems audits and internal performance audits (where applicable) to be performed, as well as information on the party(ies) responsible for performing the audits.

The corrective action procedures to be performed in response to audit findings shall be provided, together with the responsible party(ies) for implementing corrective actions, and the party(ies)

that will receive the audit reports. The types and frequencies of audits required for verification testing can be found in the Source Water Protection Pilot Quality Management Plan[3].

10.0 APPENDICES

The following shall be provided as appendices to the Test Plan:

- historical influent flow and wastewater quality data (where this data is to be used with the approval of the Verification Organization);
- effluent and residuals data from previous tests (where this data is to be used, with the approval of the Verification Organization)
- O&M manuals supplied by the Vendor;
- Environmental, Health and Safety Plan, including material safety data sheets; and,
- other documentation and data as applicable.