Test Plan

for the

Bio-Microbics RetroFAST 0.375

Under the
US Environmental Protection Agency
Environmental Technology Verification Program

at the
Mamquam Wastewater Technology Test Facility

Prepared for
NSF International
and
Environmental Technology Verification Program
of the US Environmental Protection Agency

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EXECUTIVE SUMMARY

This Test Plan is designed to verify nutrient reduction of the Bio-Microbics Inc. RetroFAST treatment technology under the US EPA Environmental Technology Verification (ETV) Program Source Water Protection Pilot. Verification testing will be carried out by NovaTec Consultants Inc. at the Mamquam Wastewater Technology Testing Facility, located in Squamish, British Columbia, Canada. During the testing, the Bio-Microbics RetroFAST 0.375 Model treatment plant will be loaded with influent wastewater from a sanitary sewer at the design hydraulic rate of 375 US gallons per day.

The period of testing will consist of an eight-week startup period, followed by a twelve-month testing period incorporating five stress periods with varying stress conditions, simulating real household conditions.

Monitoring of nutrient reduction will be by measurements of constituents which demand oxygen for treatment (BOD and CBOD), and nitrogen species (TKN, NH_4, NO_2, NO_3), along with other parameters such as alkalinity and suspended solids. Operational characteristics such as electric use, labor to perform maintenance, maintenance tasks, durability of the hardware, noise and odor production will be monitored.

Deliverables from the monitoring will be in the form of sampling event reports, water quality data summary reports, an operation and maintenance report, and a QC and analytical report.

Technology Description

Physical Layout

The Bio-Microbics RetroFAST 0.375 septic tank insert treatment system is a submerged attached-growth (fixed film) and suspended-growth treatment system, which is inserted into the second chamber of a typical two-chamber septic tank. The septic tank used for the ETV testing program will be a two-chamber 1350 US gallon (approximately 5100 L) tank. The first chamber volume is 880 US gallons (approximately 3340 L) and the second chamber is 465 US gallons (approximately 1760 L).

The first chamber acts as the primary settling chamber, after which the settled liquid flows into the second chamber. Liquid in the second chamber is drawn into the RetroFAST unit by an air lift system, with air pumped into the central unit by a remote air blower. The air entering the central unit induces a vertical lift of the wastewater from below the media, dispersing the wastewater over the surface of the media. The air also provides for vigorous mixing conditions, and supplies suspended bacteria with oxygen. The wastewater then moves down through the media, coming into contact with bacteria growing on the surface of the media.

Nitrified liquid circulates through the bottom of the central unit into the surrounding (un-aerated) anoxic zone in which de-nitrification occurs. A settling zone within the central unit provides a quiescent period to enable bacteria and other particles to settle-out, and clarified effluent to be discharged.

The only mechanical component is the remote air blower, which provides compressed air for oxygen supply and mixing to the aerated chamber. The RetroFAST 0.375 is designed to treat up to 375 US gallons (approximately 1420 L) per day

A small control panel contains an alarm, and the blower is contained in a remote housing.

Treatment Theory

Raw wastewater entering the first chamber of the septic tank undergoes primary settling. Solids settle to the bottom of the chamber where they are gradually digested and fermented under anaerobic conditions, releasing short-chain volatile fatty acids (VFAs) and ammonia to solution. These solubilized anaerobic digestion by-products, combined with fine colloidal particles (which do not

readily settle) and soluble organic and inorganic materials contained in the influent wastewater, form the constituents of the primary effluent.

The primary effluent flows into a second (anoxic) chamber of the septic tank where the RetroFAST unit is suspended. The organic constituents serve as food for the aerobic bacteria, attached to the media and held in suspension within the vigorously aerated central RetroFAST unit. The compressed air diffused into the central chamber supplies oxygen to bacteria and ensures thorough mixing. The bacteria consume organic material, forming new bacteria, and convert ammonia to nitrite and then to nitrate.

Liquid from the suspended aerated chamber flows into a quiescent zone where it mixes with the surrounding anoxic (no oxygen) liquid within the RetroFAST 0.375 unit. Facultative bacteria (bacteria which can use nitrite and nitrate as electron sources instead of oxygen) in the anoxic zone convert the nitrite and nitrate (formed in the aerated chamber) into nitrogen gas, which is released to the atmosphere, via an installed vent. The clarified liquid then passes from the RetroFAST 0.375 unit for disposal.

The focus of this evaluation will be on the wastewater discharged from the RetroFAST unit.

TABLE OF CONTENTS

EXECUTIVE SUMMARY ..... **ii**

Technology Description ..... *ii*
Physical Layout ii
Treatment Theory ii

ABBREVIATIONS ..... **vii**

1.0 INTRODUCTION **1**

1.1 Background *1*
1.1.1 Nutrient Reduction 1
1.1.2 Verification Testing 1
1.1.3 Testing Objectives 1
1.1.4 Test Site Description 2
1.1.5 Equipment Description 3

1.2 Critical Measurements *4*
1.2.1 Critical Measurement 4
1.2.2 Data Quality Objectives 4
1.2.3 Testing Plan Schedule 4
1.2.4 Milestones 5

2.0 PROJECT ORGANIZATION **6**

3.0 EXPERIMENTAL DESIGN **7**

3.1 Test Conditions *7*
3.1.1 Installation, Start-up and Repairs 7
3.1.2 System Operation 7
3.1.3 Phases of Testing 7
3.1.4 Influent Flow Pattern 7
3.1.5 Stress Testing 7

3.2 Sampling And Monitoring Locations *8*
3.2.1 Influent Wastewater 8
3.2.2 Final Effluent 8

3.3 Sampling Frequency and Types *9*
3.3.1 Sampling Frequencies 9
3.3.2 Sample Types 10

3.4 Sampling Strategy And Procedures *10*
3.4.1 Sampling Location Selection Rationale 10
3.4.2 Sample Type Selection Rationale 12
3.4.3 Sample Frequency Selection Rationale 12

3.5 Evaluation of Verification Objectives *13*
3.5.1 Evaluation of Field Measurments and Analytical Data 13

3.6 Safety And Hygiene Plan *13*

4.0 FIELD OPERATION PROCEDURES **14**

4.1 Method To Establish Steady State *14*

4.2 Site Specific Factors Affecting Sampling or Monitoring Procedures. *14*

4.3 Site Preparation Needed Prior To Sampling Monitoring *14*
4.3.1 Tee-Cross Sampling Points 14

4.4 Monitoring Procedures For The Mamquam WTTF *14*
4.4.1 Collection Of Representative Samples 14
4.5 Split Samples *14*
4.6 Sample Containers, Volumes and Holding Times *14*
4.7 Sample Labeling, Transport And Archiving *15*
4.9 Sample Transport *15*
4.10 Sample Archiving *15*

5.0 ANALYTICAL PROCEDURES 16

5.2 Reporting Units *16*
5.3 Calibrated measurements *16*
5.3.1 CanTest Calibrations 16
5.4 Other Measurements *16*
5.4.1 Influent Wastewater 17
5.4.2 Electric Use 17
5.4.3 Chemical Use 17
5.4.4 By-Product Volumes and Characteristics 17
5.4.5 Environmental Considerations 17
5.4.6 Mechanical Components 18
5.4.7 Electrical/Instrumentation Components 18
5.4.8 Residuals and Byproducts 18

6.0 QUALITY ASSURANCE PROJECT PLAN 19

6.1 QA/QC Objectives *19*
6.2 Quality Control Indicators *19*
6.2.1 Precision 19
6.2.2 Accuracy 19
6.2.3 Environmental Considerations 21
6.2.4 Representativeness 21
6.2.5 Completeness 21
6.2.6 Comparability 22
6.3 Sampling Equipment Calibration And Frequency *22*
6.3.1 Automated Sampler Calibration: 22
6.3.2 Calibration Frequency 22
6.4 Water Quality and Operational Control Checks *22*
6.4.1 Water Quality Data 22
6.4.2 Quality Control for Equipment Operation 23
6.5 Maintenance of Chain of Custody *23*
6.5.1 CoC Forms 23
6.5.2 Cooler Receipts 23
6.6 Acceptance Criteria *23*
6.6.1 Criteria For Acceptance Of Operational Facility Parameters 23
6.6.2 Criteria For Acceptance Of Technology Operational Parameters *23*
6.7 Assessment Of Additional QA Objectives (Mass Balance) 24
6.8 Corrective Action Plan *24*
6.8.1 Analytical Methods 24
6.8.2 Sample Collection, Handling and Field Measures 24
6.9 Sample Cross Contamination Preventive Measures *25*
6.10 QA Management Structure *25*

6.10.1 QA Manager 25

7.0 Reports And Other Deliverables 26

7.1 Deliverables 26
7.1.1 Sampling Report 26
7.1.2 Data Summary Report 26
7.1.3 Operation and Maintenance Report 27
7.1.4 Quality Control and Analytical Report 27

7.2 Data Reduction 27
7.2.1 CanTest Laboratory 27
7.2.2 NovaTec Consultants Inc. 28

8.0 ASSESSMENTS 29

8.1 Audits at Mamquam WTTF 29
8.1.1 Dosing Valves 29
8.1.2 Sampling 29
8.1.3 Sample Processing 29
8.1.4 Responsible Personnel 29

8.2 Audits at CanTest Laboratories Ltd. 29

8.3 Waste Management Plan 29
8.3.1 Liquid Waste 29
8.3.2 Solid Waste 29

ABBREVIATIONS

ANSI	American National Standards Institute
BMI	Bio-Microbics Incorporated
BOD_5	Biochemical Oxygen Demand (five day)
$CBOD_5$	Carbonaceous Biochemical Oxygen Demand (five day)
cfm	cubic feet per minute
CoC	Chain-of-Custody
USEPA	United States Environmental Protection Agency
ETV	Environmental Technology Verification
mg/L	milligrams per Liter
gpd	US gallons per day
gpm	US gallons per minute
L	Liters
NELAC	National Environmental Laboratory Accreditation Council
NIST	National Institute of Standards and Technology
NH_4	Ammonia
NO_2	Nitrite
NO_3	Nitrate
NO_X	Nitrite + Nitrate
NSF	NSF International
NTC	NovaTec Consultants Inc.
PQL	Practical Quantitative Limit
RPD	Relative Percent Difference
SCADA	Supervisory Control and Data Acquisition
SOP	Standard Operating Procedure
STP	Sewage Treatment Plant
TKN	Total Kjeldahl Nitrogen
TS	Total Solids
TSS	Total Suspeded Solids
WTTF	Wastewater Technology Testing Facility
WTP	Wastewater Treatment Plant

1.0 INTRODUCTION

1.1 Background

1.1.1 Nutrient Reduction

Verification of residential wastewater treatment technologies under the United States Environmental Protection Agency's (US EPA) Environmental Technology Verification (ETV) Source Water Protection Pilot Protocol for Residential Nutrient Reduction Technologies is designed to verify the nutrient removal performance of residential (individual household) wastewater treatment technologies, in addition to the removal performance of the oxygen-demanding contaminant load.

The reduction of nutrients in wastewater discharged within watersheds is desirable from two standpoints:

1. reduction of watershed nitrogen inputs helps meet drinking-water quality standards for nitrate and nitrite;
2. reduction of both nitrogen and phosphorus helps protect the water quality of receiving surface and ground waters from eutrophication and the consequent loss in ecological, commercial, recreational and aesthetic uses of these waters.

Technologies that remove nutrients in on-site domestic wastewater include the following types of biologically mediated technologies:

1. aerobic fixed film processes such as trickling filters, moving bed biofilm reactors (MBBRs), submerged media filters, sand filters, peat filters, and rotating biological contactors (RBCs);
2. aerobic suspended growth processes such as extended aeration activated sludge systems and sequencing batching reactors (SBRs);
3. soil absorption-based technologies

Removal of nutrients can also be accomplished chemically through the use of ion-exchange filters and chemical precipitation systems.

1.1.2 Verification Testing

The verification testing consists of the installation of a single residential wastewater treatment technology at the Mamquam WTTF. The testing facility has a source of suitable domestic wastewater that originates from primarily residential sources. The technologies will be dosed daily with wastewater at a rate of 100% of their rated capacity, except for periods of stress testing, using a daily flow-pattern which mimics the generation of wastewater in a residence. Dosing during stress test sequences is described in Section 3.1.5. An eight-week startup period will be followed by a twelve-month testing period.

Composite influent and effluent samples are collected on a monthly basis, with additional samples collected during the five stress periods.

1.1.3 Testing Objectives

The testing objectives include verifying the removal of nutrients and oxygen-demanding contaminants, and reporting on the operating characteristics of the test unit. The removal of influent wastewater contaminants will be determined by laboratory analyses. Nutrient analyses include ammonia-N, nitrate-N, nitrite-N, and total Kjeldahl-N. Other parameters to be measured during the testing program include: 5-day carbonaceous and total biochemical oxygen demand ($CBOD_5$ and BOD_5), total suspended solids (TSS), pH, temperature, alkalinity (as $CaCO_3$), and dissolved oxygen.

Testing will include the collection of operation and maintenance characteristics of the technology, including the performance and reliability of technology components and the level of required operator maintenance. The test will identify and assess environmental inputs and outputs including chemical usage, energy usage, generation of byproducts or residuals, noise and odors.

1.1.4 Test Site Description

The Mamquam Wastewater Technology Testing Facility (WTTF) is located at the Mamquam Wastewater Treatment Plant (WTP) which serves the District of Squamish, British Columbia. Domestic wastewater is supplied from a sanitary sewer collection system serving a catchment consisting primarily of residential houses, with minor commercial source contributions. Typical influent wastewater characteristics are as follows:

- $CBOD_5$ = 181 mg/L
- TSS = 159 mg/L
- Total Nitrogen = 40 mg/L
- Ammonia = 29 mg/L
- Alkalinity = 168 mg/L- $CaCO_3$
- pH = 7.37

Raw (influent) wastewater is pumped through a 2.5-inch diameter manifold pipeline to each test site, with an effective dosage rate (delivery rate to each test unit) of approximately 53 gpm (3.4 L/s). During dosing periods, raw wastewater is constantly circulated through the manifold pipeline to ensure the influent wastewater being dosed to the test units is “fresh”, and that solid material contained in the wastewater has not settled out. Once the wastewater has passed through the manifold pipeline, it is discharged to the headworks of the Mamquam WTP.

Method of Dosing

Dosing at each of the test sites is regulated by a pneumatic gate valve located at each of the testing sites, which is controlled by a Control Microsystems Micro16 SCADA system. The SCADA system is monitored by a National Instruments LookOut interface, which displays and logs the status of all test system components including pumps, pneumatic valves, samplers, and analogue sensors. This SCADA system enables operators to monitor the operating status of the test facility and the individual test units, and to change any of the dosing parameters (e.g. dosage volume, frequency of dosage, duration of dosing period, etc.).

Dosing rates are verified by volumetric calibration checks (i.e. measuring the volume per dose), which are carried out at each test site on a weekly basis. Daily dosage volumes are calculated by multiplying the dosage rate by the number of dosage events in a 24-hour period. The computer control program determines the number of dosage events by dividing the daily dose for each test unit by the calibrated dosage volume. The calculated daily dosage volume is verified by monitoring of the daily volume pumped from the individual test unit treated effluent sumps (i.e. multiplying the calibrated sump-pump pumping rate by the total pumping time per day).

The volume of wastewater per dose to individual test sites is controlled, and varied, by the timed operation of the pneumatic control valve. The valve is typically set to deliver approximately 4.5 gallons (17L) per dose. For the US EPA ETV testing program, the dosage frequency is set to conform to the following dosing pattern of three dosing periods per day, to represent typical periods of maximum sewage flow from a single-family residence:

- 6 a.m. – 9 a.m. 35% of total daily flow
- 11 a.m. – 2 p.m. 25% of total daily flow
- 5 p.m. – 8 p.m. 40% of total daily flow

The average total daily flow must be within 100% ± 10% of the rated capacity of the technology undergoing testing, based on a thirty (30) day average, with the exception of periods of stress testing described in Section 3.1.5. The pneumatic gate valves feeding wastewater to the test units are controlled by a SCADA system that permits timing of the individual doses to the nearest tenth of a second.

Effluent

Effluent from the test units is collected by gravity into an effluent sump at each test site, and is then pumped through a separate 2.5-inch diameter effluent line to the municipal treatment plant.

1.1.5 Equipment Description

Physical Layout

The Bio-Microbics RetroFAST 0.375 septic tank insert treatment system is a submerged attached growth (fixed film) suspended-growth treatment system, which is inserted into the second chamber of a two-chamber septic tank. The first chamber acts as the primary settling chamber, after which the settled liquid flows into the second chamber and is drawn into the RetroFAST 0.375 unit by air being pumped into the central chamber via a remote air blower, where it induces vigorous mixing conditions, and supplies suspended bacteria with oxygen. Nitrified liquid circulates through the bottom of the central chamber into the surrounding (un-aerated) anoxic zone in which de-nitrification occurs. A settling zone within the central chamber provides a quiescent period to enable bacteria and other particles to settle-out, and clarified effluent to be discharged. The only mechanical component is the remote air blower, which provides compressed air for oxygen supply and mixing to the aerated chamber. The RetroFAST 0.375 is designed to treat up to 375 US gallons per day (1420 L/d).

The RetroFAST 0.375 utilizes a 1/4 Hp regenerative blower producing 21 cfm. The media used is a PVC cross-flow media, with a total installed packed volume of 12 cubic feet. A small control panel contains an alarm, and the blower is contained in a remote housing.

Treatment Theory

Raw wastewater entering the first chamber of the septic tank undergoes primary settling. Solids settle to the bottom of the chamber where they are gradually digested and fermented under anaerobic conditions, releasing short-chain volatile fatty acids (VFAs) and ammonia to solution. These solubilized anaerobic digestion by-products, combined with fine colloidal particles (which do not readily settle), and soluble organic and inorganic materials contained in the influent wastewater, form the constituents of the primary effluent.

The primary effluent flows into a second (anoxic) chamber of the septic tank where the RetroFAST 0.375 unit is suspended. The organic constituents serve as food for the aerobic bacteria, attached and held in suspension, within the vigorously aerated central RetroFAST 0.375 unit. The compressed air diffused into the central chamber supplies oxygen to bacteria and ensures thorough mixing. The bacteria consume organic material and convert ammonia to nitrite and then to nitrate.

Liquid from the suspended aerated chamber flows into a quiescent zone where it mixes with the surrounding anoxic (no oxygen) liquid within the RetroFAST 0.375 unit. Facultative bacteria (bacteria which can use nitrite and nitrate as electron sources instead of oxygen) in the anoxic zone convert the nitrite and nitrate (formed in the aerated chamber) into nitrogen gas. The nitrogen gas formed is then released to the atmosphere via an installed vent.

The clarified liquid passes from the RetroFAST 0.375 unit into a pump chamber for pressure distribution, or by gravity to a distribution box for even distribution to subsurface trenches, or other disposal options.

Septic Tank Size

The septic tank for the RetroFAST 0.375 ETV testing is a two-chamber 1350 US gallon (5100 L) tank. The first chamber volume is approximately 880 USgal (3340 L) and the second chamber is approximately 465 USgal (1760 L).

Equipment Capacity

For normal household wastewater strength, the test unit has a manufacturer rated treatment capacity of 375 US gallons per day (1420 L/d).

1.2 Critical Measurements

1.2.1 Critical Measurement

For this test plan, a critical measurement is defined as a measurement whose absence would significantly lower the confidence in the data and would affect the ability to verify system performance. In the event data is lost or is deemed otherwise unacceptable, critical measurements must be repeated within a time period that would allow substitution so as not impair the final data set.

Critical measurements of the verification plan fall into two categories:

1 measurement and characterization of the nutrient and other contaminant removal performance of the technologies;

2 measurements and observations of technology operational characteristics.

Critical and non-critical measurements, by test specific target parameters, are indicated in Table 3-3.

1.2.2 Data Quality Objectives

Data quality objectives for the first category in 1.2.1 above involves acquiring sufficient correct analytical measurements of contaminant removal performance in order to credibly characterize the long-term removal performance of the technology under varying climatic (temperature) conditions.
The principal users of this data will be the technology vendor, Bio-Microbics Inc. to gain regulatory approvals for use in marketing. Secondary users of this data will be the various state, regional and local approval and planning authorities in the United States. Likely secondary data users also will include system installation engineers and designers and consumers.
Data quality objectives for the second category 1.2.1 are the development of sufficient correct operational and environmental data about the technology to characterize the reliability, cost and environmental operational characteristics (i.e., noise and odor) of the technology. The principal users of this data are consumers and designers. Secondary users for the information are state, regional and local approving and planning authorities in the United States.

1.2.3 Testing Plan Schedule

The testing plan schedule includes three phases:

1 Pre-installation communication between the verification organization, testing organization and the participating vendor, (Bio-Microbics Inc.) and installation of the technology, which may require up to three months;

2 Start-up period of up to eight weeks, wherein Bio-Microbics Inc. is provided with time for the technology to come to a steady-state operational condition. Bio-Microbics Inc. has the option of indicating when the technology is ready to begin testing.

3 Twelve-month operational testing period.

A detailed weekly schedule of the testing period is provided in Table 3 – 2.

1.2.4 Milestones

Milestones for the testing include:

1 completion of technology installation and start-up;
2 completion of the startup period (up to eight weeks);
3 completion of the twelve month testing period;
4 reporting of data.

2.0 PROJECT ORGANIZATION

U.S. Environmental Protection Agency (EPA):

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Sub-contract Laboratory: CanTest Laboratories Ltd. (CanTest), 4606 Canada Way. Burnaby, British Columbia, Canada. Tel: 604-734-7276 fax: 604-731-2386

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3.0 EXPERIMENTAL DESIGN

3.1 Test Conditions

3.1.1 Installation, Start-up and Repairs

The Bio-Microbics Inc RetroFAST 0.375 unit shall be assembled, installed and filled in accordance with the Bio-Microbics Inc.'s specifications at the Mamquam Wastewater Technology Testing Facility (WTTF). Bio-Microbics Inc. shall inspect the system for proper installation and, if no defects are detected and the system is determined to be structurally sound, it shall be placed into operation in accordance with Bio-Microbics Inc.'s start up procedures. If Bio-Microbics Inc. does not provide a filling procedure, 2/3 of the system's capacity shall be filled with water and the remaining 1/3 shall be with residential wastewater.

When possible, electrical or mechanical defects shall be repaired to prevent evaluation delays. All repairs shall be recorded in the test log.

3.1.2 System Operation

The system shall be operated in accordance with Bio-Microbics Inc.'s instructions. Routine service and maintenance of the system shall not be permitted during the performance and evaluation period unless performed under the direct supervision of the testing organization. All maintenance or service performed on the system during the start up and testing phase of the evaluation shall be documented in the field log.

3.1.3 Phases of Testing

The system shall undergo design loading of wastewater for a minimum of one (1) year following a maximum start-up period of eight (8) weeks. When the technology performance has stabilized during the start-up period, Bio-Microbics Inc. shall advise the Testing Organization that the evaluation period can commence. This notice shall be in writing to the Verification Organization. The one-year evaluation period will allow for an assessment of the impact of seasonal variations on performance.

3.1.4 Influent Flow Pattern

The volume of wastewater per dose to individual test sites will be controlled by the timed operation of the pneumatic control valve feeding the test unit. This valve will be set to dose approximately 4.5 gallons (17 L) per dose. The dosage frequency is set to conform to the following dosing pattern of three dosing periods per day, to represent typical periods of maximum sewage flow from a single-family residence.:

- 6 a.m. – 9 a.m. approximately 35% of total daily flow in 29 doses
- 11 a.m. – 2 p.m. approximately 25% of total daily flow in 21 doses
- 5 p.m. – 8 p.m. approximately 40% of total daily flow in 33 doses

Total daily flow shall be within 100% ± 10% of the rated capacity of the test unit (i.e. 375 gpd ± 37.5 gpd), based on a thirty (30) day average with the exception of periods of stress testing described in Section 3.1.5.

3.1.5 Stress Testing

One stress test shall be performed following every two months of normal operation during the technology evaluation, so that each of the five stress scenarios described below is addressed within the twelve (12) month evaluation period.
Stress testing shall involve the following simulations:

1 Wash-Day Stress

2 Working Parent Stress

3 Low-Loading Stress

4 Power/Equipment Failure Stress

5 Vacation Stress

Wash-day stress simulation shall consist of three (3) wash-days in a five (5) day period with each wash-day separated by a 24-hour period. During a washday, the technology shall receive the normal flow pattern (Section 3.1.4); however, during the course of the first two (2) dosing periods per day, the hydraulic loading shall include three (3) wash loads [three (3) wash cycles and six (6) rinse cycles]. The volume of washload flow to the technology will be standardized for all washloads (28 gallons or 106 Litres). Common (readily available to consumers) detergent and non-chlorine bleach shall be added to each wash load at Bio-Microbics Inc.'s recommended loading. If no instructions are provided, the use rates recommended by the detergent and bleach manufacturers shall be used. The same detergent and bleach use rates shall be used for each of the stress sequences.

Working parent stress simulation shall consist of five (5) consecutive days when the technology is subjected to a flow pattern where approximately 40% of the total daily flow is received between 6 a.m. – 9 a.m. and approximately 60% of the total daily flow is received between 5 p.m. and 8 p.m., which shall include one (1) wash load [one (1) wash cycle and two (2) rinse cycles].

Low-loading stress simulation shall consist of testing the technology for 50% of the design flow loading for a period of 21 days. Approximately 35% of the total daily flow is received between 6 a.m. – 11 a.m., approximately 25% of the flow is received between 11 a.m. – 4 p.m., and approximately 40 % of the flow is received between 5 p.m. and 10 p.m.

Power/equipment failure stress simulation shall consist of a standard daily flow pattern until 8 p.m. on the day when the power/equipment failure stress is initiated. Power to the technology shall then be turned off at 9 p.m. and the flow pattern shall be discontinued for 48 hours. After the 48-hour period, power shall be restored and the technology shall receive approximately 60% of the total daily flow over a three (3) hour period which shall include one (1) wash load [one (1) wash cycle and two (2) rinse cycles].

Vacation stress simulation shall consist of a flow pattern where approximately 35% of the total daily flow is received between 6 a.m. and 9 a.m. and approximately 25% of the total daily flow is received between 11 a.m. and 2 p.m. on the day that the vacation stress is initiated. The flow pattern shall be discontinued for eight (8) consecutive days with power continuing to be supplied to the technology. Between 5 p.m. and 8 p.m. of the ninth day, the technology shall receive 60% of the total daily flow, which shall include three (3) wash loads [three (3) wash cycles and six (6) rinse cycles].

3.2 Sampling And Monitoring Locations

3.2.1 Influent Wastewater

A composite influent wastewater sample will be collected from the same location as the influent pump feeding the test facility's manifold sewage distribution pipe. The composite sample will be made up of discrete sub-samples collected each time the test unit is dosed.

At the time the influent composite sample is sent to the laboratory for analysis, a grab sample will be withdrawn from the influent sampling point for pH and temperature measurement.

3.2.2 Final Effluent

Final effluent (composite) samples will be collected from the 3-inch effluent line of the Bio-Microbics Inc. treatment unit, from the location where the final effluent discharges into the test unit effluent sump. The composite sample will be made up of discrete sub-samples collected each time the test unit is dosed.

At the time the final effluent composite sample is sent to the laboratory for analyses, a grab sample will be withdrawn from the final effluent sampling point (during periods when flow is occurring at the sampling point), and subjected to pH, temperature and dissolved oxygen measurement.

Dissolved oxygen will be measured at the treated effluent location when flow across the sampling point is occurring. (Refer to Table 3-1).

TABLE 3–1 SAMPLING MATRIX

PARAMETER	SAMPLE TYPE	SAMPLE LOCATION		TESTING LOCATION
		INFLUENT	FINAL EFFLUENT	
BOD_5	24 Hour composite	√		Laboratory
$CBOD_5$	24 Hour composite		√	Laboratory
Suspended Solids	24 Hour composite	√	√	Laboratory
Alkalinity (as $CaCO_3$)	24 Hour composite	√	√	Laboratory
TKN (as N)	24 Hour composite	√	√	Laboratory
Ammonia (as N)	24 Hour composite	√	√	Laboratory
Nitrate (as N)	24 Hour composite		√	Laboratory
Nitrite (as N)	24 Hour composite		√	Laboratory
Dissolved Oxygen	Grab		√	Test Site
pH	Grab	√	√	Test Site
Temperature (°C)	Grab	√	√	Test Site

3.3 Sampling Frequency and Types

3.3.1 Sampling Frequencies

Normal Monthly

Sampling will normally be carried out at a minimum frequency of once per month. Additional samples will be taken in conjunction with the stress tests and the final week of sampling, as outlined in the following sections.

Stress Test

Samples will be collected on the day each stress simulation is initiated and when approximately 50% of each stress test has been completed (Note: For the Vacation and Power/Equipment failure stresses, there is no 50% sampling).

Beginning twenty-four (24) hours after the completion of washday, working-parent, low-loading, and vacation stress scenarios, samples shall be collected for six (6) consecutive days.

Beginning forty-eight (48) hours after the completion of the power/equipment failure stress, samples shall be collected for five (5) consecutive days.

Final Week

Samples will be collected for five (5) consecutive days at the end of the year-long evaluation period.

Table 3-2 shows a hypothetical sampling schedule based on the NSF/ETV Nutrient Reduction Protocol requirements.

3.3.2 Sample Types

Composite Samples

Composite samples will be collected using automated samplers at each sample collection point cited in Section 3.2.1 and Table 3.1. Automated samplers will be programmed to draw equal volumes of sample from the waste treatment stream at the same frequency, number and timing as the influent wastewater doses to the test unit. Samples taken in this manner will therefore be flow-proportional composite samples. Initiation of individual automated sampler events will be offset or delayed to correspond to the passage of a flow pulse through the relevant sample collection point.

Grab Samples

Grab samples for pH, temperature and dissolved oxygen will be obtained at the location of the automated sampler intake.

QC Samples

Each of the monthly influent and effluent composite samples will be split, and the duplicate field samples will be submitted to the laboratory for the purpose of assessing QC. The samples will not be identified to the laboratory as duplicates.

During stress testing, composite influent and effluent field samples will also be split, and the duplicates submitted to the laboratory, at least once per stress event.

Raw Sample Retention

Sample remaining in the bulk composite sample containers shall be retained at 4 degrees Celsius for 24 hours following field sampling. In the event of transportation or laboratory sample loss, this retained sample may provide additional sub-sample volume for analysis.

3.4 Sampling Strategy And Procedures

3.4.1 Sampling Location Selection Rationale

Influent Samples

The influent samples will be collected from the location of the influent pump feeding the test facility manifold, timed to coincide with the mid point of the dosing cycle (i.e. if the dose time is 12 seconds, the sampler is triggered to collect a sample at the 6-second mark). The Influent wastewater-sampling site ensures a representative sample of wastewater is obtained.

Table 3 – 2 Sampling Schedule

PERIOD	COMMENT	SAMPLES COLLECTED
Startup Period (up to 8 weeks):		once during week 3, 5, 6, and 7
Testing Period:		
Week 1-8:		Day 1 of week 4 and 8
Week 9:	**Wash Day Stress** initiated on day 1 of Week 9.	Day 1, 3, 6 and 7 of Week 9
Week 10:		Day 1, 2, 3 and 4 of week 10
Week 11-17		Day 1 of week 14 and 17
Week 18	**Working Parent Stress** initiated on Day 1 of week 18.	Day 1, 3, 6 and 7 of Week 18
Week 19		Day 1, 2, 3 and 4 of Week 19
Week 20-27		Day 1 of week 23 and 27
Week 28	**Low-loading Stress** initiated on Day 1 of Week 28	Day 1 of Week 28
Week 29-30		Day 4 of Week 29
Week 31		Day 1, 2, 3, 4, 5, and 6 of Week 31
Week 32-38		Day 1 of week 35 and 38
Week 39	**Power/Equipment Failure** stress initiated on Day 1 of Week 39	Day 6 and 7 of Week 39
Week 40		Day 1, 2 and 3 of Week 40
Week 41-47		Day 1 of week 44 and 47
Week 48	**Vacation Stress** initiated on Day 1 of Week 48	Day 1 of Week 48
Week 49		Day 4, 5, 6 and 7 of Week 49
Week 50		Day 1 of Week 50
Week 51		No sample will be taken this week
Week 52		Day 1, 2, 3, 4 and 5 of Week 52

- NOTE: Duplicate (split) samples are to be collected once per month during routine testing and once during each stress test period.

Intermediate Technology Effluent (Not Required for the Bio-Microbics Inc. RetroFAST 0.375 test)

Effluent Samples

The effluent sample will be collected from the location at which the test unit discharges into the effluent sump. During installation and setup of the Bio-Microbics unit, a sampling point consisting of a tee-cross with a "J" pipe of sufficient size to retain sample volume for both grab and automated sampler will be installed on the end of the discharge end of the test unit. Note that the piping is only large enough to

retain approximately one liter of fluid and be readily flushed and replenished by the normal flow of treated effluent. The sump is also be accessible so that it may be cleaned of attached and settled solids on a regular basis prior to sampling dates.

3.4.2 Sample Type Selection Rationale

The ETV SWPP Nutrient Reduction Protocol, for which this plan is intended, dictates selection of the types of samples, grab or composite. The selection of composite samples for the majority of parameters reflects the tendency of a composite sample to provide a more representative sample in the face of the established daily variability of influent wastewater strength and character, and is a compromise with sample holding time restrictions. In contrast, grab samples for pH, temperature and dissolved oxygen are parameters best measured from fresh sample obtainable as a grab.

3.4.3 Sample Frequency Selection Rationale

The ETV SWPP Nutrient Reduction Protocol has established selection of the frequencies of sampling. Samples shall be collected at a minimum interval of once per month at all sampling locations (See Table 3-2).

Table 3- 3 Test Specific Target Parameter Table

Operational Venue	Measurement Type	Target Analytes or Measure	Critical	Non-Critical
Influent Wastewater	Chemical Analysis	BOD5	X	
		pH		X
		Alkalinity	X	
		TKN	X	
		Ammonia (as N)	X	
	Assay	Suspended Solids	X	
	Physical	Temperature		X
		Volume	X	
Final Effluent	Chemical Analysis	CBOD5	X	
		pH		X
		Alkalinity	X	
		TKN	X	
		Ammonia (as N)	X	
		Orthophosphate (as P)	X	
		Dissolved Oxygen		X
	Assay	Suspended Solids	X	
	Physical	Temperature		X
Byproducts/ Residues	Assay	TSS	X	
		VSS		X
	Physical	Volumetric	X	
Environmental	Assay	Noise		X
		Odor		X
Operation & Maintenance	Physical	Power Consumption	X	
Monthly Alarms Test		Alarm light and Buzzer		X
Electrical Components		Failure/Bearings/Deterioration of control/junction boxes		X
Structural Integrity & Hydrostatic		Operator Observation		X

3.5 Evaluation of Verification Objectives

3.5.1 Evaluation of Field Measurments and Analytical Data

The data produced by the field analytical measures at the Mamquam WTTF will be evaluated as falling within acceptable QA/QC limits for those measures, based on performing a calibration check (i.e.DO and pH measurements) and measurements with a duplicate device (i.e. temperature measurement), as described in the Mamquam SOP (Appendix A). Validation includes calibrations, test procedures, acceptance criteria and documentation of results.

Laboratory analytical data will be evaluated for acceptance based on the data falling within QA/QC limits as reported by CanTest Laboratories, and outlined in the laboratory QA protocol for the parameters analyzed during this test (Attachment 2).

Measurements of influent flow will be evaluated for acceptance on the basis of meeting the stated QA/QC objectives for those measures based on two methods of measurement (weekly volumetric dosage checks and effluent sump pumped volumes), as described in the Mamquam SOP (Appendix A).

Observations of the Bio-Microbics test unit operational characteristics, environmental characteristics and measures, and alarm tests will be evaluated on the basis of these measures compliance with the relevant QA/QC requirements for recording observations, electric use and alarm tests as described in the Mamquam SOP (Appendix A).

3.6 Safety And Hygiene Plan

The Mamquam WTTF safety plan and the CanTest Laboratories Ltd. health and safety plan are on file and can be made available upon request.

4.0 FIELD OPERATION PROCEDURES

4.1 Method To Establish Steady State

Bio-Microbics Inc will advise NovaTec when the technology is ready for commencement of evaluation. Alternately, the Bio-Microbics Inc may indicate the parameter values that indicate the system is ready. As noted in the protocols, this period may not extend beyond 8 weeks, but may, at Bio-Microbics Inc.'s prerogative, be shorter.

4.2 Site Specific Factors Affecting Sampling or Monitoring Procedures.

There are no site-specific factors affecting sampling or monitoring procedures.

4.3 Site Preparation Needed Prior To Sampling Monitoring

4.3.1 Tee-Cross Sampling Points

Installation of PVC tee-cross sampling location in the effluent sump will be required during the installation of the Bio-Microbics technology. This tee-cross will be installed as described in section 3.4.1.

4.4 Monitoring Procedures For The Mamquam WTTF

4.4.1 Collection Of Representative Samples

The collection of representative samples is ensured through the use of automated composite-samplers, which will be used to collect all major samples, except grab samples for the purposes of measuring pH, temperature and dissolved oxygen. The automated samplers are programmed to trigger when given a 12V DC pulse controlled by the SCADA unit. The SCADA unit also provides a 24V pulse to trigger the pneumatic gates valves to dose the test unit. Each of the sampling and dosing events is displayed and recorded digitally (number of events in a 24 hour period) and graphically on a micro-computer, which is attached to the SCADA unit monitoring and controlling the facility equipment. The SCADA unit synchronizes sampling with influent dosing events, and ensures that effluent samples collected are flow (dose)-proportional.

Sample volumes delivered by the automated samplers are self-calibrated by the sampler and verified by recording the total volume collected on the composite sample bottle. Irregularities in sample volumes can be detected by verifying that the total sample volume is the same each day. This is simply carried out by operations staff through comparison with liquid levels in the sample container.

Vigorous mixing of the composite sample container while sub-sampling into sample bottles for transport to CanTest laboratories ensures the sub-samples are representative of the original composite sample. Comparison of duplicate results and laboratory QA/QC results can be used to assess sampling and analytical error.

4.5 Split Samples

As noted above, the comparison of duplicate sample results and laboratory QA/QC results can be used to assess sampling and analytical error. The identity and presence of split samples (duplicates) is known only by NovaTec operations personnel (i.e. blind samples).

4.6 Sample Containers, Volumes and Holding Times

Sample containers, volumes and holding times are shown in Table 4 – 1

4.7 Sample Labeling, Transport And Archiving

Samples will be labeled with the standard CanTest adhesive label. Information required to complete this label includes the following items of information: (Dummy data in parenthesis)

- Sample Client: (NovaTec)
- Sample Date: (1/1/01)
- Time of Collection: (09:15)
- Location: (Mamquam WTTF)
- Sampling ID: (NT-P09-S05)
- Collected by: (Wayne)
- Analysis Requested (BOD, CBOD, NO_3, NO_2, NH_4, TKN, TSS, alkalinity)
- Preservative: (None, H2SO4, etc.)

4.9 Sample Transport

Samples will be transported to CanTest Laboratories via courier. The samples will be shipped in coolers packed with ice to maintain the temperature of all transported samples at 4^o C. Travel time from the Mamquam WTTF to CanTest is approximately 75 minutes. Travel blanks will be used during the test, as described in Section 6.4.1.

4.10 Sample Archiving

The remaining sample of raw composite will be retained for 24 hours at 4^oC at the Mamquam WTTF.

Table 4–1 Sample Holding-Time Requirements

ANALYTE	LOCATION	CONTAINER	HOLDING TIME
BOD_5	Influent	250 ml Nalgene	48 hr
$CBOD_5$	Effluent	1 liter Nalgene	48 hr
Suspended Solids	Influent	250 ml Nalgene	7 days
Suspended Solids	Effluent	1 liter Nalgene	7 days
PH	All	250 ml sample cup	[1]
Temperature	All	250 ml sample cup	[1]
Alkalinity	All	250 ml Nalgene	14 days
Dissolved Oxygen	Effluent	250 ml sample cup	[1]
TKN[2]	All	250 ml acidified bottle	28 days
Ammonia[2]	All	250 ml acidified bottle	28 days
Total Nitrate/Nitrite	Effluent	250 ml Nalgene	48 hr

1. pH, Temperature and D.O. will be measured immediately following recovery of sample
2. TKN and Ammonia use a common pre-acidified bottle for all locations.

The holding times are maximum allowable under the EPA methods – per Std. Methods, 19th Ed.)

5.0 ANALYTICAL PROCEDURES

5.1 Water Quality Methods

Water quality parameters and analytical methods are listed in Table 5-1.

Table 5-1 Water Quality Analytical Methods

PARAMETER	FACILITY	ACCEPTANCE CRITERIA		METHOD STANDARD
		Duplicates (%)	Spikes (%)	
BOD_5	CanTest Laboratories	80-120	N/A	Method #5210 B*
$CBOD_5$	CanTest Laboratories	80-120	N/A	Method #5210 B
Suspended Solids	CanTest Laboratories	80-120	N/A	Method #2540 D
pH	On-site	90-110	N/A	Method #423
Temperature (^oC)	On-site	90-110	N/A	Method #2550
Alkalinity	CanTest Laboratories	80-120	N/A	Method #2320
Dissolved Oxygen	On-site	80-120	N/A	Method #4500
TKN (as N)	CanTest Laboratories	80-120	80-120	EPA 351.4**
Ammonia (as N)	CanTest Laboratories	80-120	80-120	EPA 350.1
Total Nitrite (as N)	CanTest Laboratories	90-110	60-140	EPA 353.3
Total Nitrate (as N)	CanTest Laboratories	90-110	60-140	EPA 353.3

*Standard Methods for the Examination of Water and Wastewater, APHA, 20th ed., (2000).
**Methods for Chemical Analysis of Water and Wastes, US EPA, EPA-600/4-790-20, Revised (1983(and Methods for the Determination of Inorganic Substances in Environmental Samples, US EPA, EPA/600/R-93/100, (1993).

5.2 Reporting Units

Reporting units are listed in Table 6–1

5.3 Calibrated measurements

5.3.1 CanTest Calibrations

Calibration procedures for analytes measured at the CanTest facility in Table 5-1 are contained in the CanTest Laboratories SOP available at CanTest.

5.4 Other Measurements

Measurement of operational facility and technology parameters other than those listed in Tables 5-1, include volume of influent wastewater dosed to the Bio-Microbics technology, electric use, chemical use, and by-product volumes and environmental consideration (noise and odors).

5.4.1 Influent Wastewater

Information about how the volume of dosed wastewater will be determined should be inserted here.

5.4.2 Electric Use

Mamquam WTTF operations personnel, as indicated on the dedicated electric meter serving the Bio-Microbics unit, will record electrical use biweekly in the Field Log. The meter's manufacturer and model number and any claimed accuracy for the meter will also be noted in the Field Log. Following the end of the testing period the electric meter will be checked for calibration, and the calibration data will be entered in the Field Log.

5.4.3 Chemical Use

The Bio-Microbics unit does not add process chemicals to achieve treatment.

5.4.4 By-Product Volumes and Characteristics

The by-products of the RetroFAST 0.375 unit consist of the treated effluent and septage remaining in the tank after testing is completed.

The volume of effluent discharged from the test unit is estimated using an hour meter attached to the effluent sump pump and monthly calibration measurements of the sump pump discharge rate. The sump pump hour meter is recorded on a daily basis by Mamquam WTTF operations personnel.

The amount of septage generated shall be assessed by measuring the sludge depth in the tank at the end of testing, and also by mixing the contents of the tank and tanking samples for total solids (TS) analysis. The quanity of solids contained in the tank will be estimated by multiplying the TS value by the liquid volume in the tank.

A further description of byproduct measurement procedures can be found in Section 5.4.8.

5.4.5 Environmental Considerations

Noise

Noise levels associated with mechanical equipment will be verified during the evaluation period using a decibel meter. Measurements will be taken one metre (3 feet) from the source(s) at one and a half meters above the ground, at 90° intervals in four (4) directions. Any mitigation measures for noise control provided by the Bio-Microbics Systems Inc. shall be noted.

Noise levels shall be measured once during the evaluation, approximately one month after completion of start-up period. The meter shall be calibrated prior to use. Meter readings shall be recorded in the Field Log. Three measurements at each quadrant shall be made to account for variations in ambient sound levels, and these replicate values will be recorded in the operations log for the test unit.

Noise measurements will be made at times of the day when ambient noise levels are at their lowest (i.e. on a weekend morning and when wind speed is at a minimum).

Odors

The Mamquam WTTF operations personnel will make monthly observations during the evaluation period with respect to odors generated by the Bio-Microbics technology. The observation shall be qualitative and shall include odor strength (intensity) and type (attribute). Intensity shall be as non-detectable; barely detectable; moderate; and strong. Observations shall be made during periods of low wind velocity (<10 knots) and will be made standing upright at a distance of three (3) feet from the treatment unit, at 90°

intervals in four (4) directions. All observations shall be by the same Mamquam WTTF personnel, to the extent possible.

If the treatment system is buried, covered or otherwise has odor containment, the means of ventilating the compartment(s), including any odor treatment systems shall be noted in the Field Log.

5.4.6 Mechanical Components

Performance and reliability of the mechanical components (pump & air compressor) shall be observed and documented during the test period. This will include the recording in the Field Log of equipment failure rates, replacement rates, and the existence and use of duplicate or standby equipment.

Alarms

During the evaluation period, any alarm systems associated with the technology shall be operationally tested and verified at least once per month. The Bio-Microbics has two alarms to indicate high and low water conditions, respectively that are activated by floats in the pump chamber. Lifting floats to activate shall operate these alarms. Responses of the alarms (Does the alarm sound or not?) to testing shall be recorded in the Field Log. (The vendor will be contacted to verify the activation of the alarm will not modify the plant operating cycle. If it does, the testing will not be done, and the fact that testing would change the operation of the system will be noted in the field log.)

5.4.7 Electrical/Instrumentation Components

Electrical components, particularly those that might be adversely affected by the corrosive atmosphere of a wastewater treatment process, and instrumentation and alarm systems shall be monitored for performance and durability during the course of verification testing. Observations of physical deterioration shall be noted in the Field Log. Electrical equipment failure rates, replacement rates, and the existence and use of duplicate or standby equipment shall be noted and recorded in the Field Log.

5.4.8 Residuals and Byproducts

Byproducts or residuals, when generated, may include septage and sludge. The quantity and quality of residuals generated during the evaluation process will be recorded in the Field Log. Measurement of sludge depth will be made twice during the testing period: once after six months and once in the final month of testing. A coring sludge measurement tool (Sludge-Judge) will be used to estimate the depth of sludge/solids in the first chamber and second chamber of the 1,300 gallon septic tank. Measurement of the depth and areal extent of the solids deposits will be recorded in the Field Log.

In the event residuals/solids are removed as a matter of regular operation and maintenance of the technology, the volume, mass and other characteristics of the byproducts or residuals (such as TSS, VSS, water content) shall be recorded in the Field Log.

Samples of the residuals/solids retained in each compartment of the tank during the evaluation shall be recovered from the Sludge-Judge during the final measurement period (month 14). The contents of the Sludge-Judge shall be emptied into a clean container, and the sample shall be analyzed for water content, TSS and VSS. Following this measurement and sampling, the contents of the tank will be vigorously mixed, as samples will be taken for total solids analysis.

6.0 QUALITY ASSURANCE PROJECT PLAN

6.1 QA/QC Objectives

One QA/QC objective of this plan is to ensure that strict methods and procedures are followed during the verification program so that the data obtained from the testing are valid for use for the NSF ETV Nutrient Reduction Protocols. Another QA/QC objective is to ensure that the conditions under which data are obtained are properly recorded and can be directly linked to the data, should a question arise as to its validity.

6.2 Quality Control Indicators

6.2.1 Precision

Precision is defined as the degree of mutual agreement relative to individual measurements of a particular sample. As such, Precision provides an estimate of random error. Precision is evaluated using analysis of field or matrix spiked duplicates. Method precision is demonstrated through the reproducibility of the analytical results. Relative percent difference (RPD) may be used to evaluate Precision by the following formula:

$$RPD=[(C_1- C_2) \div ((C_1 + C_2)/2)] \times 100\%$$

Where:

C_1= Concentration of the compound or element in the sample
C_2= Concentration of the compound or element in the duplicate

Please refer to Table 6-1 for field and laboratory methods for determination of precision.

6.2.2 Accuracy

For water quality analyses, accuracy is defined as the difference between the measured or calculated sample result and the true value for the sample. The closer the numerical value of the measurement comes to the true value or actual concentration, the more accurate the measurement. Loss of accuracy can be caused by errors in standards preparation, equipment calibrations, interferences, and systematic or carryover contamination from one sample to the next.

Analytical accuracy may be expressed as the percent recovery of a compound or element that has been added to a sample at known concentrations prior to analysis. The following equation is used to calculate percent recovery:

$$\text{Percent Recovery} = (A_r-A_o)/A_f \times 100\%$$

Where:

A_r= Total amount detected in spiked sample
A_o= Amount detected in un-spiked sample
A_f= Spike amount added to sample.

Analytical Accuracy

Analytical accuracy will be assessed using prepared and analytical standards, as appropriate. Analytical accuracy is ensured by following individual analytical method SOPs and random spiking procedures for specific target constituents. Please refer to Table 6-1 for analytical method accuracy.

Field Sample Accuracy

Field sample accuracy will be ensured for analyses conducted at the Mamquam WTTF by use of the calibration standards and calibration procedures outlined in the Mamquam SOP (Attachment A)

Field Process Systems Accuracy

Accuracy of influent dosing volumes are measured during the test program, and ensured by weekly calibration checks of the dosage volume which are recorded in the operations log, along with the dosing valve open time.

Table 6 – 1 Methodology for Measurement of Precision and Accuracy

Parameter	Precision	Accuracy
BOD_5 (Report to the nearest 1 mg/l)	One sample per sample event or 10% of sample batch.	CanTest Laboratories SOP
$CBOD_5$ (Report to the nearest 1 mg/l)	One sample per sample event or 10% of sample batch.	CanTest Laboratories SOP
Suspended Solids (Report to the nearest 1 mg/l)	One sample per sample event or 10% of sample batch.	CanTest Laboratories SOP
Alkalinity (Report to the nearest 1 mg/l)	One sample per sample event or 10% of sample batch.	CanTest Laboratories SOP
TKN (Report to the nearest 0.1 mg/l)	One sample per sample event or 10% of sample batch.	CanTest Laboratories SOP
Ammonia (Report to the nearest 0.1 mg/l)	One sample per sample event or 10% of sample batch.	CanTest Laboratories SOP
Total Nitrate/Nitrite (Report to the nearest 0.1 mg/l)	One sample per sample event or 10% of sample batch.	CanTest Laboratories SOP
PH **(report to nearest 0.1 pH unit)**	One sample per sample event or 10% of sample batch.	Daily 3-point calibration with certified pH buffers in range of measurements (4.0-10.0)
Temperature (report to nearest 0.1 ^{o}C)	One sample per sample event or 10% of sample batch.	Quarterly verification against CanTest Laboratories NIST thermometer.
Dissolved Oxygen **(report to nearest 0.5 mg/l)**	One sample per sample event or 10% of sample batch.	Daily calibration to internal standard and reference to table of saturation values.

For equipment operating parameters, accuracy refers to the difference between the reported operating condition and the actual operating condition. For operating data, accuracy entails collecting a sufficient quantity of data during operation to be able to detect a change in system operations.

Influent Dosing Flow Rate

As previously noted, influent dosing is controlled by a micro-processor based SCADA control unit. The SCADA unit controls the duration and the number of times per day the pneumatic gate valve feeding the test unit is open. The time open and total number of dosages each day is automatically recorded and graphically displayed on a microcomputer for easy operator verification. Dosage volumes are verified on volumetrically once per week as described in the Mamquam SOP (Appendix A), and daily dosage volumes are verified by daily recording of the effluent pump hour-meter and calibrated pumping flow rates.

Electrical Usage

Accuracy of electrical usage measurement will be assured by regular biweekly recording of meter readings. Accuracy of the meter itself as claimed by the meter manufacturer shall be noted along with model number and serial number of meter. Following the end of the testing period the electric meter will be re-calibrated, and the calibration data will be entered in the Filed Log.

Chemical Usage

Chemical use is not applicable to the Bio-Microbics, as no process chemicals will be added to the treatment process.

6.2.3 Environmental Considerations

Noise

The sound meter for measurement of noise levels will be calibrated prior to use and the calibration information will be noted in the Field Log. Accuracy will be ensured by conforming to ANSI/NSFI Standard 40 protocols for noise measurement (Refer to Section 5.4.3 above).

Odor

Use of the term accuracy is not appropriate for a qualitative measurement instrument (the human nose). However, the consistency of measurement of the monthly observations of odors will be ensured by use of consistent location of measurement instrument (the human nose), consistency on odor description or type, odor intensity and the measurement timing (Refer to Section 5.4.3 above for method of observations).

6.2.4 Representativeness

Representativeness is the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition

Analytical Procedures

Proper handling will ensure representativeness of laboratory procedures, storage and analysis of samples so that the test results reflect the collected sample as accurately as possible. (I don't know if this wording is any better, but I didn't understand the other.)

Field Samples

The representativeness of field samples will be assessed by the collection of field duplicates covering the range of concentrations for the particular parameter of interest encountered in this verification Test Plan. Field sample representativeness is ensured by the use of composite sample for influent and effluent samples.

6.2.5 Completeness

Start-Up Period Completeness

Start-up completeness shall be determined either by Bio-Microbics Inc. direction to begin testing, or by the completion of the eight week start-up period, whichever comes first.

Analytical Results Completeness (Twelve-Month Sampling Period)

Influent Volumetric Measurements

Influent flow data completeness shall be determined as 85% of the total number of dosing days being valid and acceptable.

Electric Use

Electric use completeness shall be determined as 83% of the biweekly meter readings.

Sampling

Completeness of sampling for **monthly samples** shall be determined as 83% of valid sampling data from the monthly tests.

Completeness of sampling for **stress tests** will be determined as 83% valid sampling data from each of the stress tests.

Analytical Results Completeness

Analytical results completeness will be determined as 90% of samples delivered to CanTest Laboratories shall be valid and acceptable.

6.2.6 Comparability

Comparability of data for CanTest Laboratories is ensured by the regular participation in completing PE samples as part of laboratory certification.

6.3 Sampling Equipment Calibration And Frequency

6.3.1 Automated Sampler Calibration:

Calibration is accomplished using a subroutine in the regular sampler program. The sampler calibration procedure discharges a 100 mL sample volume into the composite sampling container. The sampled volume is then transferred to a graduated cylinder to measure and verify the sampled volume. The sampled volume is then entered into the calibration program, and the sample volume is adjusted accordingly. The sample volume is then re-verified by manually activating the sampler, and measuring the resulting sample volume using a graduated cylinder.

6.3.2 Calibration Frequency

The sampler shall be calibrated monthly to ensure that equal samples are drawn and that sufficient sample volume is drawn for the necessary analysis sub-samples. The amount normally drawn for each of the 100 samples is between 75 and 90 milliliters. This provides a total composite sample of between 7.5 and 9.0 Liters.

6.4 Water Quality and Operational Control Checks

6.4.1 Water Quality Data

Spiked samples for each method will be analyzed at the rate outlined in the CanTest Laboratories SOP and QA plans.

Method blanks will be analyzed at the rate outlined in the CanTest SOP and QA Plan.

Travel blanks will be provided to CanTest Laboratories twice during the sample period.

CanTest shall complete PE samples for analyses completed in this evaluation at least every six months during the course of the evaluation. Results of the PE samples shall be made available to the Verification Organization during project audits.

6.4.2 Quality Control for Equipment Operation

Laboratory analytical instruments shall be checked for accuracy based upon the SOP and QA plans for CanTest Laboratories.

All analytical and sampling equipment at the Mamquam WTTF will be maintained and calibrated by Mamquam WTTF personnel according to the manufacturer's instructions and according to the Mamquam WTTF SOP.

6.5 Maintenance of Chain of Custody

6.5.1 CoC Forms

Chain of custody forms (CoC) shall be filled out in triplicate prior to sample transportation. If the person transporting the samples is not the field sampler, the chain of custody form will indicate the transfer of samples. A copy of the CoC shall be retained at the Mamquam WTTF for records.

Samples will be transported from Mamqaum WTTF to CanTest Laboratories in coolers packed with ice, immediately following completion of sample collection. Travel time to CanTest Laboratories is approximately 75 minutes.

Upon receipt of samples at the CanTest laboratory, the sample custodian notes date of receipt, client demographic information, the condition of samples and documents any deficiencies. If the sample integrity or identification are in doubt the event is documented on a Sample Problem Form and the relevant individuals are notified immediately.

6.5.2 Cooler Receipts

Cooler receipts will be part of the chain of custody forms. The receipt will include the observed condition of samples and the sample temperature.

6.6 Acceptance Criteria

Analytical acceptance criteria for QA objectives for each matrix are listed in Table 5-1. The criteria are contained in the CanTest Laboratories SOP available upon request. Acceptance criteria for pH, temperature and dissolved oxygen are discussed in Mamquam WTTF SOP.

6.6.1 Criteria For Acceptance Of Operational Facility Parameters

Influent wastewater dose volumes are calibrated weekly with a volumetric test. Acceptance criteria for the measurements shall be that the 30-day average volume of the wastewater delivered to the technology shall be within 100% +/- 10% of the systems rated hydraulic capacity. An exception to this volume shall be during the Low Flow Stress Test when the 21-day average volumes accepted will be 100%+/- 10% of the daily reduced flow (50% of normal daily flow volume). For purposes of calculating the 21-day average volume, only the 21 days of the Low Flow Stress period are to be included.

6.6.2 Criteria For Acceptance Of Technology Operational Parameters

Electrical use is manually recorded from the dedicated electric meter and criteria are the meter reading, and pertinent Field Log notations (date, time recorder's name). Accuracy of the meter as claimed by the manufacturer shall be noted in the Field Log. The meter shall be recalibration following the end of the Test Period and the recalibration results entered in the Field Log.

6.7 Assessment Of Additional QA Objectives (Mass Balance)

The use a mass balance approach to removal performance is not contemplated at this time.

6.8 Corrective Action Plan

6.8.1 Analytical Methods

Corrective actions for analytical methods (listed in Table 5-1) performed are outlined in the CanTest Laboratories SOP. When analytical parameters fall outside of the relevant acceptance criteria, corrective action will be taken to rerun samples. Such actions may include: re-analysis of sample and standards; re-analysis with appropriate fresh reagents and standards. Corrective action may also take the form of measures to prevent future occurrence of the problem. Any problems with analysis will be noted in the relevant laboratory logbook and corrective actions taken will also be recorded in the laboratory logbook.

6.8.2 Sample Collection, Handling and Field Measures

Corrective actions for field sampling and field analytical procedures at the Mamquam WTTF are included in the Mamquam WTTF SOP. Whenever necessary or appropriate, shortcomings in the execution of this test plan revealed by audits will be corrected

Sample Collection

Nonconformance of sample collection with procedures in this Test Plan and the Mamquam WTTF SOP will be noted in the Field Log. Likewise any corrective action taken will be recorded in the Field Log. Nonconformance can include: automated sampler malfunction due to electrical fault; improperly programmed sampler controller; failure to initiate sampler program; movement of suction line and loss of suction.

Sample Handling

Nonconformance with sample handling and transport will be recorded in the Field Log and any corrective action taken recorded in the Field Log.

Field Analytical Measurement

Nonconformance with field measures refers to measurement of Temperature, pH, and Dissolved Oxygen made at the Mamquam WTTF. Measurements that fall outside the acceptance criteria for these analyses will be noted in the Field Log. Corrective action shall be taken and noted in the Field Log.

For pH, corrective actions can include: measurements with the pH meter which appear to be anomalous can be repeated; buffers can be checked between measurements; sample duplicates are run at the prescribed rate in this document; the meter can be recalibrated, or recalibrated with fresh buffers, and the sample(s) re-analyzed.

Temperature is measured with a separate thermistor probe, and subsequently measured with a second thermistor on the pH probe. Corrective actions may include re-measurement of temperature.

Dissolved oxygen problems can include excessive drift during measurement; excessive temperature shift during measurement; and failure to agitate probe sufficiently during measurement. When problems with measurement occur, corrective actions may include: re-measurement; recalibration of the meter and probe; replacement of meter batteries with fresh; and replacement of probe membrane. Measurements that fall outside of the acceptance criteria for these analyses will be noted in the Field Log. Corrective action shall be taken and noted in the Field Log.

6.9 Sample Cross Contamination Preventive Measures

Composite sample containers shall be uniquely labeled identifying the technology, and sample location. Composite sample bottles are thus dedicated to a single technology and sampling point throughout the testing period. In the field facility, to minimize cross contamination while processing analytical sub-samples and during field analytical measurements, samples will be processed beginning with the most highly treated effluent, then intermediate effluent and last the wastewater influent.

6.10 QA Management Structure

6.10.1 QA Manager

Dr. Troy D. Vassos, P.Eng.
Senior Process Engineer
NovaTec Consultants Inc.
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Vancouver, British Columbia, Canada V5Y 1N5
Tel: 604-873-9262
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Responsibilities: Mamquam WTTF Director; QA Manager
Qualifications: PhD Environmental Engineering – Environmental Data Analysis

7.0 Reports And Other Deliverables

The data reporting parameters, reporting units, and method of recording are shown in Table 7.1 below.

Table 7-1 Data Reporting Table

Parameter	Reporting Units	Matrix		Method
		Influent	Effluent	
BOD_5	Milligrams/liter	X		3.5" disk Paper
$CBOD_5$	Milligrams/liter		X	3.5" disk Paper
Suspended Solids	Milligrams/liter	X	X	3.5" disk Paper
pH	pH units	X	X	3.5" disk Paper
Temperature	Degrees C.	X	X	3.5" disk Paper
Alkalinity	Milligrams/liter ($CaCO_3$)	X	X	3.5" disk Paper
Dissolved Oxygen	Milligrams/liter		X	3.5" disk Paper
TKN	Milligrams/liter	X	X	3.5" disk Paper
Ammonia as N	Milligrams/liter	X	X	3.5" disk Paper
Total Nitrite as N	Milligrams/liter		X	3.5" disk Paper
Total Nitrate as N	Milligrams/liter		X	3.5" disk Paper
Influent Wastewater	Gallons per day	X		3.5" disk Paper

7.1 Deliverables

The following are deliverables from NovaTec Consultants Inc.:

7.1.1 Sampling Report

A Sampling Report will be completed and submitted for each sampling event during the evaluation period following all sampling activities. This report will consist of a brief summary of the major actions performed, any problems encountered since the previous report, and corrective actions taken to correct problems. This information will be kept in project files along with the CoC forms and the Field Log documenting the sampling activities.

7.1.2 Data Summary Report

NovaTec will provide a Data Summary Report consisting of tabulated summaries of the data including startup data to the Verification Organization in both electronic and hard copy format. The summaries will show the sample identifiers, the analyses performed, and the measured concentration or effects, including all relevant qualifiers and validation flags. A brief narrative statement on the overall data quality and quantity will also accompany the tabulated summaries. The NovaTec Project Manager will coordinate with the Laboratory Project Manager to define the format of these data summary reports. The NovaTec Project Manager shall also forward all data summary reports to the Verification Organization Project Manager following review.

7.1.3 Operation and Maintenance Report

An Operation and Maintenance Report will be provided of the operation and maintenance activities that are performed during the verification-testing period, by the NovaTec Project Manager or Mamquam WTTF Operator. The report will consist of a summary of the recommended operation and maintenance activities for the technology and any additional operation or maintenance tasks that were required during the test period. This report shall clearly delineate when the Bio-Microbics Systems Inc. (BMI) provided technical assistance to the Testing Organization.

The Operation and Maintenance Report will also comment upon the BMI O&M manual as it relates to the 12 month operation and maintenance record of the BMI technology. Comments could include: maintenance needed but not covered by the manual; clarification of the BMI O&M language, etc.

7.1.4 Quality Control and Analytical Report

A Quality Control and Analytical Report will be used to address the quality control practices employed during the project. The report will also summarize the problems identified in the sampling reports, which are likely to impact the quality of the data. The report will include:

1) The project description, including report organization and background information
2) Summaries of the sampling procedures, sample packaging, sample transportation, and decontamination procedures at the Mamquam WTTF.
3) A summary of the CanTest laboratory analytical methods, detection limits, quality control activities, deviations from planned activities, and a summary of the data quality for each analysis and matrix.
4) An assessment of the sampling and analyses techniques, an evaluation of the data quality of each parameter, and an evaluation of the usability of the data.
5) A summary of any field or analytical procedures that could be changed or modified to better characterize the raw influent and treated effluent in future evaluations.
6) An overall discussion of the quality of the environmental data collected during the evaluation and whether or not it meets the project objectives.
7) Identification of the QA samples that were split and sent to CanTest and QA laboratories and to the QA laboratory.
8) All cooler receipts and COC forms associated with the required sample results.
9) A laboratory case narrative to be included in the results if nonconformance or other evaluation events affect the sample results.
10) The portion of the primary field sample results and associated batch QC results, which conform to the QA samples submitted to the QA laboratory.

7.2 Data Reduction

7.2.1 CanTest Laboratory

Data reduction procedures for the CanTest Laboratory analysis of parameters are contained in the SOPs for each analyte/parameter.

7.2.2 NovaTec Consultants Inc.

NovaTec field staff will do data reduction for influent flow calculations. The daily wastewater flow into the technology will be derived and reduced based on the procedures outlined in the Mamquam WTTF SOP.

8.0 ASSESSMENTS

8.1 Audits at Mamquam WTTF

NovaTec field personnel will conduct audits of dosing pump calibrations, sampling and sample processing on a quarterly basis. For audits, a checklist of operations performed will be created.

8.1.1 Dosing Valves

For the dosing valve calibrations the checklist will include calibration equipment set-up procedures, calibration procedure, and logging of calibration results.

8.1.2 Sampling

For sampling the audit checklist will include composite container preparation, installation and retrieval, sampler calibration check, and sampler programming.

8.1.3 Sample Processing

For sample processing the audit checklist will include the setup, calibration and measurement of pH and D.O. meters, the measurement of temperature, the splitting of the composite sample into sub-sample containers, use of the CoC, and sample preservation and transport.

8.1.4 Responsible Personnel

Personnel who are responsible for the above audits are: Dr. Troy Vassos, P.Eng., NovaTec Consultants Inc. Audits will be kept on file for reference by NSF.

8.2 Audits at CanTest Laboratories Ltd.

CanTest laboratory audits are regularly conducted by CanTest personnel for each analytical method in the Test Plan.

8.3 Waste Management Plan

8.3.1 Liquid Waste

Liquid waste generated by the Testing Organization consists of: raw wastewater and process effluent from sample collection; 2% dilute bleach (sodium hypochlorite); and small volumes of pH and conductivity standards. These are disposed of into the sink and toilet drains at the test site. The effluent enters the facility sewer system to be treated at the Mamquam wastewater treatment plant. Liquid waste generated by the Testing Organization does not enter or mix with the Test Facility influent wastewater.

8.3.2 Solid Waste

Solid waste generated at the testing Organization consists of paper and cardboard and other packaging materials. Disposal of these wastes are to the District of Squamish solid waste transfer plant. Residuals left in the BMI septic tank and process tank are mixed (liquified) and pumped into the Mamquam WWTP digesters to be treated.