City of St. Joseph, Missouri

Facilities Plan

Class A Biosolids Certification

By

BLACK & VEATCH

Work Order No. 09-001
B&V Project 163509

May 4, 2010

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Tables

Appendices

Class A Biosolids Certification

1.0 Executive Summary

This technical memorandum (TM) provides information on the proposed process for a pathogen equivalency recommendation from the United States Environmental Protection Agency (USEPA). This TM also discusses the experiences of a wastewater facility that obtained Class A equivalency from the USEPA.

The anaerobic digestion process at the St. Joseph Water Protection Facility (WPF) consists of two-stage thermophilic digestion followed by a single-stage mesophilic digester. The plant is considering options to qualify its treated biosolids as Class A solids. In order to meet the USEPA's Class A requirement, the pathogen treatment process must meet defined operating criteria or the densities of pathogens in the treated solids must be lower than dictated levels.

The existing residuals treatment process at the St. Joseph WPF does not meet USEPA's Class A requirement as defined by the "time and temperature" criteria presented in 40 Code of Federal Regulations (CFR) Part 503. As an alternative to meet the requirement "by definition", the City can measure pathogens in the biosolids and demonstrate compliance with the Class A criteria. The biosolids are considered Class A if the pathogen density levels meet the Class A requirement for enteric viruses, helminth ova, and fecal coliform (or *Salmonella* spp.) densities at the time the biosolids are land applied or given away. However, this "measurement" alternative can be costly because the analyses of some pathogens (e.g., enteric viruses and viable helminth ova) are expensive.

In lieu of measurement, the City can pursue a Class A equivalency designation for the treatment process. If the process is certified as meeting Class A equivalency, measurement requirements for enteric viruses and helminth ova are reduced or eliminated.

The equivalency application includes four steps, as follows:

- The City contacts USEPA Region VII or the Pathogen Equivalency Committee (PEC) to initiate the application.

- The City works with the PEC in an iterative process to prepare a Quality Assurance Project Plan (QAPP).
- After the QAPP is approved by the PEC, the City submits an application for equivalency, including process description, equivalency application forms, and test results. The PEC makes equivalency recommendations based on the data and information submitted. Once a recommendation for equivalency has been issued, the City is required to generate an operations and maintenance (O&M) manual for the process dictating specified operating parameters and additional conditions.
- After the O&M manual is received, the equivalency recommendation is forwarded to the USEPA Office of Science and Technology (OST) for review. The OST provides the official letter of recommendation and a copy of the O&M manual to the permitting authority (USEPA Region VII). The permitting authority has the option of accepting or rejecting the PEC recommendation.

The details of equivalency application, the criteria the PEC uses to determine the qualification of an equivalency application, and a case study of a wastewater treatment facility that has received Class A equivalency are described in this TM.

It is recommended that the City contact USEPA Region VII or the PEC to initiate the application and begin an iterative process to prepare a QAPP. After the QAPP has been finalized, then a budget and monitoring activities can be completed by the City.

2.0 Background

The St. Joseph WPF has a continuous feed anaerobic digestion system consisting of two-stage thermophilic digesters at 131° F, followed by an unheated digester operating at a mesophilic temperature of 104° F. The digested solids are stored in an unheated mixed secondary digester (storage tank) before dewatering. Dewatered solids are either land applied on local agricultural land or stored at a temporary storage facility. Based on plant data from 2005 through 2009, the average digester feed rate is 14.5 dry tons per day (dtpd) with a flow of 45,100 gallons per day (gpd). Operations staff indicate that the plant currently produces 3,640 dry tons of solids per year (dtpy). Based on the historical digester feed flow, the hydraulic retention time (HRT) in the digesters is listed in Table 1.

Table 1 Digester Detention Time		
Tank	**Tank Volume, cf**	**Detention, Days**
Historical Values – Based on 45,100 gpd (14.5 dtpd) Digester Feed		
Thermophilic Tank 1	258,000	66
Thermophilic Tank 2	155,000	40
Mesophilic Tank	155,000	40
Future Design Values – Based on 182,500 gpd (29.8 dtpd) Digester Feed		
Thermophilic Tank 1	258,000	11
Thermophilic Tank 2	155,000	6
Mesophilic Tank	155,000	6

The USEPA Class A "time and temperature" alternative requires solids to be held for a specified time at a given temperature. For solids with concentrations of less than 7 percent total solids (TS), the equation is as follows:

$$D = \frac{50{,}070{,}000}{10^{0.1400t}}$$

Where D = time in days
T = temperature in degrees Celsius

Based on the thermophilic operating temperature of 131° F (55° C) used at St. Joseph, the required detention time is 24 hours. Since the USEPA requires that all solids be held for the necessary detention time, at least one of the thermophilic tanks must be able to operate in a batch or semi-batch mode. As an alternative to batch or semi-batch operation, facilities with tanks in series may be able to meet the time and temperature requirement if it can demonstrate that the process approximates plug flow treatment. This typically requires tracer testing and usually requires three tanks or more in series.

An alternative to the "time and temperature" requirement for Class A material is to measure pathogens in the biosolids at the time they are used or disposed. The biosolids are Class A if the densities of fecal coliforms and/or pathogens in the biosolids meet the following criteria at the time of its use, disposal, or sale:

- Either the density of fecal coliforms is less than 1,000 Most Probable Number (MPN) per gram of total solids (dry weight basis) or the density of *Salmonella* spp. bacteria is less than three MPN per four grams of total solids (dry weight basis).
- The density of enteric viruses is less than one Plaque-forming Unit (PFU) per four grams of total solids (dry weight basis).
- The density of viable helminth ova is less than one per four grams of total solids (dry weight basis).

Helminth ova and enteric virus testing is challenging and expensive, making the pathogen measurement option costly. Testing frequencies are listed in the 40 CFR Part 503 requirements and are based on total annual solids production. St. Joseph WPF, which currently produces 3,640 dtpy solids, would be required to monitor the pathogens mentioned above every 60 days (six times per year). This monitoring frequency would be expected to be the same at the future solids production conditions. In comparison, if a Class A equivalency has been established, only fecal coliform or *Salmonella* spp. must be analyzed, unless special requirements for monitoring are imposed by the permitting authority.

3.0 Procedures for Equivalency Application

The PEC of the USEPA is responsible for evaluating effectiveness of treatment processes that do not meet the Class A pathogen criteria by definition. The PEC has developed procedures for applying for pathogen equivalency (Appendix A).

The four phases in the equivalency recommendation process are:

I. Initiation Phase
II. Quality Assurance Project Plan (QAPP) Phase
III. Application Phase
IV. Notification Phase

A flow chart of the equivalency recommendation process is provided in Appendix A. These phases are discussed in further detail in the following sections. Obtaining a recommendation for equivalency requires thorough examination of the solids treatment process and could take three or more months from the time the PEC receives a completed application.

3.1 Initiation Phase

The USEPA is responsible for the pathogen equivalency process and directs this process through its regional coordinators. Each USEPA region has the option of directing the application process itself or deferring to the PEC. Based on conversations with USEPA Region VII, the St. Joseph WPF should direct inquiries directly to the PEC and should provide information copies to Region VII staff. Missouri Department of Natural Resources (MDNR) has the authority to impose more stringent requirements on the application. Appendix B includes the contact information for the Region VII and MDNR biosolids coordinators.

3.2 Quality Assurance Project Plan Phase

Applicants (i.e., the City) are required to prepare a QAPP to provide a framework for testing the treatment process. A QAPP is a written document that provides a blueprint to ensure that the sampling and testing process produces reliable data that can be used to determine pathogen equivalency. During the development of the QAPP, it is useful to discuss the approach with the regional coordinators and the PEC. This helps ensure that the QAPP meets the PEC requirements.

A guidance document (QAPP Guidelines for Applied Research Projects) is included in Appendix C. This document contains information on requirements for the project description and objectives, project organization, experimental approach, sampling procedures, testing and measurement protocols, quality assurance/quality control checks, data reporting, data reduction, data validation, assessments, and references.

After the plan is submitted to the USEPA, the PEC reviews the plan using a completeness checklist (Appendix D). The plan is refined and revised, using an iterative process between the PEC and the City. While data collection would typically begin after the QAPP is approved, there have been instances where data collected during the development of the QAPP has been used for the PEC review. The sampling period and suitability of existing data are discussed during the development of the QAPP.

3.3 Application Phase

After the QAPP has been finalized and sampling completed, a Pathogen Reduction Equivalency Application Package (Appendix E) is prepared. The package includes a process description consisting of operating conditions, performance, and reliability; the application for equivalency recommendation; a copy of the QAPP; and test results. The application package must be notarized by a Notary Public. The application packages must be submitted to both the USEPA regional coordinator and the PEC.

The PEC review process varies, but is expected to take at least three months. The PEC can recommend the following:

- Full equivalency,
- Conditional or restrictive equivalency,
- Not equivalent, or
- More information necessary to make a determination.

If the PEC finds the process to be equivalent but the data is not sufficient to make a recommendation of full equivalency, the PEC will issue either a conditional or restrictive equivalency recommendation. A conditional equivalency includes additional conditions and/or constraints under which the process must be run. Restrictive equivalencies include site restrictions similar to those required for Class B biosolids. Once a recommendation of equivalency has been issued, the City will be required to generate an O&M manual for the process that dictates how to remain within the specified operating parameters and additional conditions.

3.4 Notification Phase

Once the O&M manual is received, the equivalency recommendation is forwarded to the USEPA Office of Science and Technology for review and approval. The Office of Science and Technology generates an official letter of recommendation, which is provided to the permitting authority (USEPA Region VII) with a copy of the O&M manual for the biosolids processes. The permitting authority has the option of accepting or rejecting the PEC recommendation.

4.0 Equivalency Criteria

The PEC uses the following four criteria when evaluating equivalency:

- Identification of critical process parameters
- Verification of pathogen reduction
- Demonstration of successful scale-up
- Appropriate documentation of field and laboratory procedures

4.1 Identification of Critical Process Parameters

The treatment process must be well-defined. The PEC requires a detailed process description, including diagrams and discussions of the disinfection stressors (physical, chemical, and/or biological) that are employed (i.e., time, temperature, pH).

4.2 Verification of Pathogen Reduction

The City must demonstrate that its treatment process meets the process efficiency and process compliance requirements listed in Table 2. If the solids feed to the full scale digesters does not naturally contain the required number of enteric viruses or helminth ova, the PEC may require the City to perform bench or pilot-scale testing with pathogen spiking to demonstrate compliance. Practical aspects for a process to further reduce pathogens (PFRP) equivalency are summarized in Appendix F. A list of certified laboratories that can perform the microbial tests and budget costs are listed in Appendix G.

Table 2 Criteria for Demonstrating Pathogen Reduction Mandatory Minimum Requirements	
	PFRP Equivalency
Process Efficiency Parameters	1. ≥ 3 log reduction of total enteric viruses, **and** 2. ≥ 2 log reduction of viable helminth (*Ascaris*) ova, **and** 3. ≥ 3 log reduction of fecal coliform bacteria
Process Compliance Parameters (40CFR503 Requirements)	Organism densities in the treated sludge of: 1. < 1 PFU/4 g TS of total enteric viruses, **and** 2. < 1 viable helminth (*Ascaris*) ova/4 g TS, **and** 3. < 1,000 MPN fecal coliform/g TS **or** 4. < 3 MPN *Salmonella* spp./4 g TS (applicant's choice)
PFRP: a process to further reduce pathogens PFU: plaque forming unit TS: total solids MPN: most probable number	

If desired, the pathogens listed in Table 3 can be measured in place of fecal coliform to demonstrate process efficiency. However, fecal coliform or *Salmonella* spp. must be measured to demonstrate process compliance.

Table 3 Optional Organisms for Process Efficiency [1]	
	PFRP Equivalency
Any of the organisms listed can be quantified ***instead of or in addition to only*** the fecal coliform parameter listed in Table 1	≥ 3 log reduction of *E. coli* bacteria **and/or** ≥ 3 log reduction of *Enterococcus* spp. bacteria **and/or** ≥ 3 log reduction of *Salmonella* spp. bacteria
1. Should any of the optional organisms be used in place of fecal coliform, fecal coliform or *Salmonella* spp. analysis on the treated sludge will still be required to meet the mandatory process compliance parameters. PFRP: a process to further reduce pathogens	

4.3 Demonstration of Successful Scale-Up

Equivalency recommendations are scale specific. If the process efficiency and process compliance parameters listed in Table 1 and Table 2 are demonstrated at bench- or pilot-scale, the City may be required to show that the process is capable of performing reliably at the full-scale in order to receive a full-scale equivalency.

4.4 Appropriate Documentation of Field and Laboratory Procedures

All data submitted to the PEC must be accompanied by documentation showing that the data collection was conducted in accordance with USEPA approved quality assurance/quality control requirements and all assays were conducted using USEPA or USEPA approved methods of analysis.

5.0 Case Study – Inland Empire Utilities Agency, Rancho Cucamonga, California

In 2001, the application for Class A pathogen equivalency by the Inland Empire Utilities Agency's (IEUA) Regional Plant No. 1 (RP1) was approved by the USEPA Region IX office. IEUA's application and USEPA's approval letter are included in Appendix H. The IEUA worked with Region IX during the application process. Douglas Drury, former Executive Manager of Operations of IEUA, provided the following information on the application process:

- USEPA did not provide specific guidelines for sampling locations and sampling frequencies. Over the course of several months, IEUA had many discussions with the Region IX USEPA coordinator on preparation of the QAPP. However, the QAPP was approved within 30 days of submission.
- IEUA submitted nine months of data to USEPA during the application process.
- Fecal coliforms, *Salmonella* spp., enteric viruses, and helminth ova were measured as part of the QAPP. After digestion, fecal coliforms were below the detection limit; *Salmonella* spp. exhibited 1-log reduction; enteric viruses exhibited 2-log reduction; and helminth ova were not detected in either thickened primary sludge or digested sludge.
- IEUA was not required to spike sludge to demonstrate process efficiency on pathogen reduction, although USEPA's guideline states that a PFRP equivalency process needs to be able to show 3-log reduction for enteric viruses and 2-log reduction for helminth ova.

- The plant continued to sample and monitor pathogens and report to USEPA on a regular basis after the equivalency was issued.

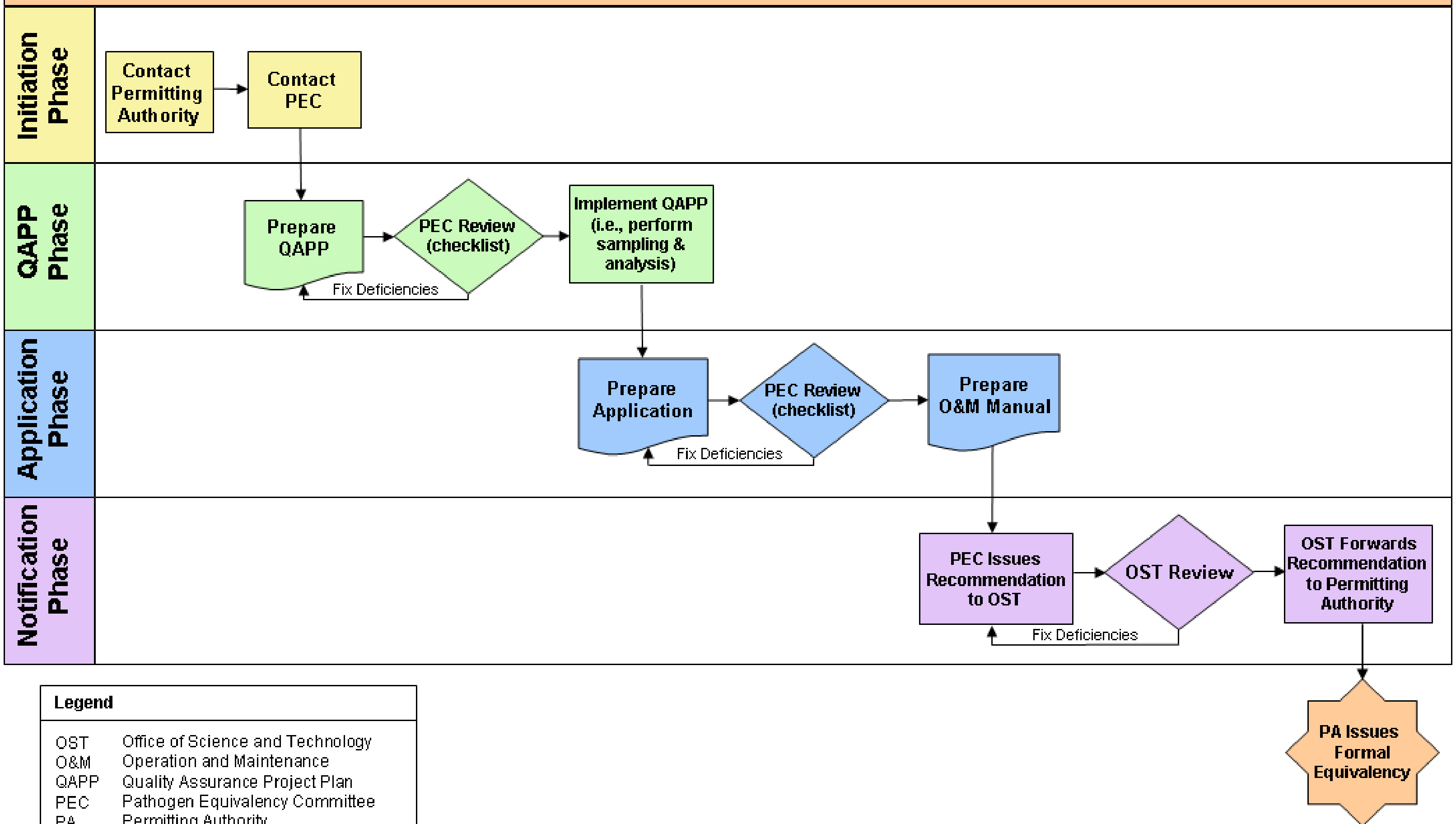
The IEUA RP1 was approved for Class A equivalency for its thermophilic digestion process. The application process extended over three months of discussion and required at least nine months of data. It should be noted that although IEUA received equivalency, it no longer needs to produce a Class A material and has since discontinued testing to reduce costs and oversight effort.

Based on discussions with USEPA and the experience from IEUA, obtaining a Class A equivalency would be expected to take at least six months or more. If enteric viruses and helminth ova are not present in the digester feed, the USEPA may require the City of St. Joseph to test or “spike” with pathogens to determine treatment effectiveness.

Appendix A

Equivalency Recommendation Process Flow Chart

The Equivalency Recommendation Process



Legend

OST	Office of Science and Technology
O&M	Operation and Maintenance
QAPP	Quality Assurance Project Plan
PEC	Pathogen Equivalency Committee
PA	Permitting Authority

Appendix B

Regional and State Biosolids Coordinator Contact Information

Regional and State Biosolids Coordinator Contact Information

United States Environmental Protection Agency Region VII

Tanya Nix, WIMB
EPA Region VII
901 N. 5th Street
Kansas City, Kansas 66101
Tel: 913-551-7170
Fax: 913-551-7765
nix.tanya@epa.gov

Berla Jackson-Johnson, WENF
EPA Region VII
901 N. 5th Street
Kansas City, Kansas 66101
Tel: 913-551-7720
Fax: 913-551-7765
jackson-johnson.berla@epa.gov

Missouri Department of Natural Resources

Tony Dohmen
MO DNR
P.O. Box 176
1101 Riverside Drive
Jefferson City, Missouri 65102
Tel: 573-751-1398
Fax: 573-522-9920
tony.dohmen@dnr.mo.gov

Appendix C

QAPP Guidelines for Applied Research Projects

QAPP GUIDELINES FOR
APPLIED RESEARCH PROJECTS

An applied research project is a study to demonstrate the performance of technologies under defined conditions. These studies are often pilot- or field-scale. The following guidelines should be addressed as applicable.

TITLE PAGE

TABLE OF CONTENTS

DISTRIBUTION LIST - A distribution list shall be provided to facilitate the distribution of the most current version of the QAPP, project reports, and other project correspondence to all the principal project participants.

SECTION 1.0 PROJECT DESCRIPTION AND OBJECTIVES

1.1 A concise project definition or general overview shall be described. The purpose of study shall be clearly stated.

1.2 The process to be tested and the plant/facility at which the testing is to take place shall be described. The process should be broken down into its key steps and each step should be clearly defined. Use of flow diagrams is encouraged. All pertinent background information regarding the process itself or sludge characteristics to be tested should be discussed.

1.3 An overview of the project's sampling plan and a description of the key parameters which will be measured shall be presented.

1.4 Project objectives shall be clearly stated and identified as primary or non-primary.

1.5 All project tasks shall be defined along with a project schedule, timeline, Gantt chart, or table indicating projected initiation and completion dates.

SECTION 2.0 PROJECT ORGANIZATION AND MANAGEMENT

2.1 Key points of contact for each organization involved in the project shall be identified. Use organization charts for clarity if needed. Any preferred communication pathways should be identified.

2.2 Responsibilities of all project participants and their relationship to other project participants shall be identified. Organizations/individuals responsible for planning, coordination, sample collection, sample custody, measurements (i.e., analytical, physical, and process), data reduction, data validation, and report preparation shall be clearly identified. Qualifications and/or resumes should be provided for key personnel, such as project managers and the laboratory(s) and person(s) performing the microbiological analysis.

2.3 Any specialized training or certification should be identified if required (e.g., OSHA's confined space entry training would be necessary to install a flow meter in a sewer main or specialized training may be necessary to conduct some of the microbiological techniques involved in demonstrating equivalency). The procedure for which the specialized training/certification is necessary should be identified. Documentation verifying completion of (or proof of timely registration for) the training/certification involved in the identified procedure must be provided.

SECTION 3.0 EXPERIMENTAL APPROACH

3.1 The general approach and the test conditions for each experimental phase shall be provided in detail.

3.2 All details of the experimental design and/or sampling strategy shall be included.

3.3 Sampling/monitoring points for all measurements (including locations and access points) shall be identified. Use of flow diagrams or maps to specify sampling/monitoring points is encouraged.

3.4 The frequency of sampling/monitoring events, as well as the numbers for each sample type and/or location shall be provided, including quality control (QC) and reserve samples.

3.5 All measurements or parameters of interest (i.e., analytical [e.g., chemical, microbiological, assays], physical [e.g., temperature], and process [e.g., flow rate]) shall be identified for each sample. Project-specific target analytes shall be listed and classified as critical or noncritical in the QAPP.

3.6 Evidence must be presented to demonstrate that the design/strategy is appropriate for meeting primary project objectives, i.e., a description of the statistical method or scientific rationale used to select sample sites and number of samples shall be provided.

SECTION 4.0 SAMPLING PROCEDURES

4.1 Sample/Monitoring Data Collection:

a. Each sampling/monitoring procedure to be used shall be discussed or referenced.
b. If compositing, splitting, or subsampling samples, those procedures shall be described.
c. Any site preparation needed prior to sampling/monitoring shall be described.

d. Known site-specific factors that may affect sampling/monitoring procedures shall be described.
e. The QAPP shall include a discussion of the procedures to be used to assure that representative samples are collected.
f. Whenever applicable, the method used to establish steady-state conditions shall be described (e.g., sampling port was flushed for a minimum of 30 seconds before collecting sample).
g. If sampling/monitoring equipment is used to collect critical measurement data, the QAPP shall describe how cross-contamination between samples is avoided.

4.2 A list of sample quantities to be collected, and the sample amount required for each analysis, including QC sample analysis, shall be specified.

4.3 Containers used for sample collection, transport, and storage for each sample type shall be described with respect to type of container, cleaning procedures, and pretreatment, if any.

4.4 Sample Handling:
a. Procedures for transporting, and packing and shipping samples shall be described.
b. For samples requiring a split sample for either quality assurance (QA)/QC purposes or for shipment to a different laboratory, the QAPP shall identify who is responsible for splitting samples, and where the splitting is performed (e.g., field versus lab).
c. Sample preservation methods (e.g., refrigeration, acidification, etc.), including specific reagents, equipment, and supplies required for sample preservation shall be described.
d. Holding time requirements shall be noted.

4.5 Sample Labeling and Management:
a. The method for labeling and uniquely identifying each sample shall be described.
b. Procedures to maintain chain-of-custody (e.g., custody seals, records) during transfer from the field to the laboratory, in the laboratory, and among contractors and subcontractors shall be described to ensure that sample integrity is maintained and to document essential information such as date and time of sample collection and amount of elapsed time between sampling and analysis.
c. Sample archival requirements for each relevant organization shall be provided.

SECTION 5.0 TESTING AND MEASUREMENT PROTOCOLS

5.1 The analytical method to be used for each analyte or parameter of interest shall be described in detail and/or referenced. Detection limits for each method should be listed.

5.2 Standard or EPA-approved methods shall be referenced by number for easy identification. Any modifications to EPA-approved or similarly validated methods shall be specified regardless of how small or insignificant they may seem.

5.3 For unproven methods, all steps to the method must be described in detail. Any verification data applicable to expected matrices shall be included in the QAPP meaning the QAPP shall provide evidence that the proposed method is capable of achieving the desired performance.

SECTION 6.0 QA/QC CHECKS

6.1 The QAPP shall include quantitative acceptance criteria for QA objectives associated with accuracy (matrix spikes), precision (agreement of replicate analyses), detection limits, and completeness for critical measurements. For each specified QA objective, required frequencies, associated acceptance criteria, and corrective actions to be performed if acceptance criteria are not met shall be included.

6.2 Any additional project-specific QA objectives shall be presented, including acceptance criteria. This includes items such as mass balance requirements.

6.3 The QAPP shall list and define all QC checks and/or procedures (e.g., blanks, surrogates, positive and negative controls, etc.) used for the project, both field and laboratory. For each specified QC check or procedure, required frequencies, associated acceptance criteria, and corrective actions to be performed if acceptance criteria are not met shall be included.

6.4 If sampling/monitoring equipment is used to collect critical measurement data (i.e., used to calculate the final concentration of a critical parameter), the QAPP shall describe how the sampling equipment is calibrated, the frequency at which it is calibrated, and the acceptance criteria for calibration or calibration verification, as appropriate.

6.5 For measurements which require a calibrated system or piece of laboratory equipment, the QAPP shall include specific calibration procedures applicable to each project target analyte, and the procedures for verifying both initial and continuing calibrations (including frequency and acceptance criteria, and corrective actions to be performed if acceptance criteria are not met).

SECTION 7.0 DATA HANDLING PROCEDURES

7.1 If data is to be collected by an outside source, the following data acquisition requirements shall be included in the QAPP.

a. The deliverables expected from each organization responsible for field and/or laboratory activities shall be listed.

b. The required format for the data should be specified (spreadsheet, tabular, etc.)

c. The reporting requirements (e.g., units, reporting method [wet or dry]) for each measurement and matrix shall be identified.

7.2 The following data management items shall be discussed.

a. The method and person or persons responsible for collection, organization, and data entry (if required) for chain-of-custody forms should be stated.

b. If laboratory bench sheet are to be used, the method and person or persons responsible for collection, organization, and data entry should be stated. An example bench sheet should be included.

c. Data storage and backup requirements for each organization shall be provided.

7.3 Data review/validation/verification procedures specific to each organization used to ensure the reporting of accurate project data to internal and external clients shall be summarized. Frequency of data review for QA/QC measures should be specified.

7.4 Data reduction procedures specific to the project, and also specific to each organization, shall be summarized (e.g., arithmetic mean, geometric mean, etc.). All statistical analyses applied to the data must be specified. Treatment of values below the limit of detection (non-detects) should be stated.

7.5 Any interim reports and the final product document that will be prepared for the project shall be specified with respect to timing, content, person or persons, responsible for preparation and anticipated recipients.

SECTION 8.0 ASSESSMENTS/OVERSIGHT

8.1 The QAPP shall identify all scheduled audits (i.e., both technical system audits and performance evaluations) to be performed, who will perform these audits, and who will receive the audit reports. If audit checklists are to be used and example should be included.

8.2 The QAPP shall provide procedures that are to be followed that will ensure that necessary corrective actions will be performed. The responsible party(-ies) for implementing corrective actions shall be identified.

SECTION 9.0 REFERENCES

References shall be provided either in the body of the text as footnotes or in a separate section.

Appendix D

PEC Equivalency Application / QAPP Completeness Checklist

PEC EQUIVALENCY APPLICATION/QAPP COMPLETENESS CHECKLIST

Project/Site Name:______________________________

Applicant:______________________________

Address:______________________________

Telephone:______________________________

Project/Site Description:______________________________

Review Type: G Equivalency Application G QAPP

Review Decision: G Complete G Incomplete

Number of Critical Elements Missing: ______________

Date Received:__________ **Date Review Concluded:**__________

Reviewer:______________________________

PROJECT OBJECTIVES AND MANAGEMENT ELEMENTS

Corresponding Section # from Guidelines		Required EPA Elements & Information	Present (Y/N/NA)	Location of Element in Submitted Document (Section #, Table #, Figure #, etc)	Comment
Application	QAPP				
X	X	Title Page			
X	X	Table of Contents			
NA	X	Distribution List			
X	NA	Summary Fact Sheet			
1.0	1.1	Project Definition/General Overview			
		Project Purpose			
		Type of Equivalency Sought (PSRP, PFRP, other)			
		Scope of Equivalency Sought (national, site specific)			
	1.2	General Plant/Facility Description			
2.0		Process Description			
		Pertinent Background Information on the Process			

Corresponding Section # from Guidelines		Required EPA Elements & Information	Present (Y/N/NA)	Location of Element in Submitted Document (Section #, Table #, Figure #, etc)	Comment
Application	QAPP				
2.0, cont.	NA	Breakdown of Key Steps			
		Materials/Additives Specifications			
		Treatment Type and Capacity			
		Process Streams Quantification and Qualification			
		Process Parameter Description			
		Process Parameter Monitoring			
		Process Uniformity and Reliability			
		Sludge Pretreatment Requirements			
NA	1.2	Pertinent Background Information on the Raw Sludge			
NA	1.3	Project Overview			
		Key Parameter Description			
NA	1.4	Project Objectives			
NA	1.5	Summary of Project Tasks			
		Project Schedule Timeline Table			
NA	2.1	Project Organization			
		Project Organization Chart(s)			
		Communication Pathways			
NA	2.2	Personnel Responsibilities			
		Personnel Qualifications/Resumes			

*Critical for Completeness

Corresponding Section # from Guidelines		Required EPA Elements & Information	Present (Y/N/NA)	Location of Element in Submitted Document (Section #, Table #, Figure #, etc)	Comment
Application	QAPP				
NA	2.3	Special Training/Certification Requirements			
3.0	NA	Climate Description			
		Discussion of Climatic Effect on Process			

MEASUREMENT / DATA HANDLING ELEMENTS

Corresponding Section # from Guidelines		Required EPA Elements & Information	Present (Y/N/NA)	Location of Element in Submitted Document (Section #, Table #, Figure #, etc)	Comment
Application	QAPP				
4.0	3.1	General Experimental Approach			
	3.2	Experimental Design/Sampling Strategy			
	3.3	Sample Locations			
		Sample Location Map			
	3.4	Sampling Frequency			
		Number of Samples			
	3.5	Parameters of Interest			
	3.6	Experimental Design/Sampling Strategy Rationale			
5.0	4.1	Sampling/Monitoring Procedures			
		Compositing/Splitting/Subsampling procedures			
		Sample Representativeness			
		Cleaning & Decontamination of Equipment			
	4.2	Sample Quantities			
	4.3	Sample Container Types			
		Sample Container Cleaning and Pretreatment			
	4.4	Sample Transport, Planning, and Shipping Procedures			
		Sample Preservation Methods			
		Sample Holding Times			
NA	4.5	Sample Container Labeling			

Corresponding Section # from Guidelines		Required EPA Elements & Information	Present (Y/N/NA)	Location of Element in Submitted Document (Section #, Table #, Figure #, etc)	Comment
Application	QAPP				
NA	4.5, cont.	Sample Chain of Custody & Tracking System			
		Sample Archival Requirements			
6.0	NA	Spiking Option Used			
		Native Level of Target Organisms			
		Spiking Method Description			
7.0	5.1	Analytical Methods			
		Detection Limits			
	5.2	Standard/EPA-Approved Methods Numbers			
		Standard/EPA-Approved Methods Modifications			
	5.3	Unproven Methods Details			
		Unproven Methods Verification			
8.0	6.1	Accuracy Requirements, Frequency, Acceptance Criteria, and Corrective Actions			
		Precision Requirements, Frequency, Acceptance Criteria, and Corrective Actions			
		Detection Limit QA Objectives			
		Completeness Requirements, Frequency, Acceptance Criteria, and Corrective Actions			
	6.2	Project-Specific QA Objectives			
	6.3	Blanks, Positive Controls, and Other QC Checks, Frequency, Acceptance Criteria, and Corrective Actions			
	NA	Comparison of QA/QC to Collected Data			
		Laboratory Qualifications			

Corresponding Section # from Guidelines		Required EPA Elements & Information	Present (Y/N/NA)	Location of Element in Submitted Document (Section #, Table #, Figure #, etc)	Comment
Application	QAPP				
NA	6.4	Sampling/Monitoring Equipment Calibration			
	6.5	Laboratory Equipment/Instrumentation Calibration			
NA	7.1	Data Acquisition Deliverables			
		Data Format Requirements			
		Data Reporting Requirements			
	7.2	Data Management of Chain-of-Custody Sheets			
		Data Management of Laboratory Bench Sheets			
		Laboratory Bench Sheet Example			
		Data Storage and Backup Requirements			
	7.3	Data Review/Validation/Verification Procedures			
	7.4	Data Reduction Procedures			
		Statistical Analysis Procedures			
		Treatment of Non-detects			
	7.5	Interim Report Timing and Frequency			
		Interim Report Content and Preparation Responsibilities			
		Interim Report Recipients			
		Final Document Timing			
		Final Document Content and Preparation Responsibilities			
		Final Document			
		Final Document Recipients			

RESULTS / DATA PRESENTATION ELEMENTS

Corresponding Section # from Guidelines		Required EPA Elements & Information	Present (Y/N/NA)	Location of Element in Submitted Document (Section #, Table #, Figure #, etc)	Comment
Application	QAPP				
9.0	NA	Discussion and Interpretation of Results			
		Appropriate Table Headings / Figure Captions			
		Interpretation of Table/Graphs in Text			
		Process Parameter Means			
		Process Parameter Variability			
		Observed Trends in Monitored Data			
		Upsets in Process Parameters and Corrective Actions			
		Sludge Type and Age			
		Sludge Quantity			
		Chemical Characteristics of the Untreated Sludge			
		Formation of Harmful By-Products			
		Sludge Temperature (Before and After Treatment)			
		Moisture/Total Solids Content (Before and After Treatment)			
		Volatile Solids Content (Before and After Treatment)			
		Means and Variability in Microbiological Results			
		Exceedances in Microbial Targets Identified and Quantified			
		Means and Variability in Log Reductions			
		Appropriate Units			

ADDITIONAL ELEMENTS

Corresponding Section # from Guidelines		Required EPA Elements & Information	Present (Y/N/NA)	Location of Element in Submitted Document (Section #, Table #, Figure #, etc)	Comment
Application	QAPP				
NA	8.1	Project Assessment Plan			
		Audit Checklists			
	8.2	Assessment Findings & Corrective Action Responses			
10.0	NA	Type and Scope of Equivalency Restatement			
		Literature Information Summary			
		Microbiological Data Summary			
		Contributing Process Parameters Review			
		Monitoring Data Summary			
		Independence of Location Discussion			
Appendix	9.0	References			
Appendix	NA	Raw Data			

Appendix E

Pathogen Reduction Equivalency Application Package

United States Environmental Protection Agency
Pathogen Equivalency Committee

Pathogen Reduction Equivalency Application Package For Biosolids Treatment Processes

(PLEASE CAREFULLY READ ATTACHED INSTRUCTIONS BEFORE COMPLETING THIS APPLICATION)

A. Nature of Equivalency Request: Select the appropriate boxes indicating the level of pathogen destruction achieved and the equivalency status for which you are seeking a determination.

Pathogen Reduction Achieved	**Level of Equivalency Sought**
☐ Process to Significantly Reduce Pathogens (PSRP)	☐ National
☐ Process to Further Reduce Pathogens (PFRP)	☐ Site-Specific

B. Applicant Information:

Name: ______________________
Mailing Address:
____
____

Contact Person: ______________________
Contact Title: ______________________
Mailing Address: ______________________
____
____
Telephone No.: (   )   -

C. Facility Information (if applicable):

Name: ______________________
Facility Location: ______________________
____
____

Contact Person: ______________________
Contact Title: ______________________
Mailing Address: ______________________
____
____
Telephone No.: (   )   -

D. Treatment Process Name:

E. Process Description: Provide a brief overall description of the biosolids treatment process being evaluated for equivalency.

F. Comparison to Established Pathogen Reduction Processes: Does the proposed process meet the operating conditions of an established pathogen reduction alternative as listed in 40CFR Part 503? Yes ☐ No ☐

If Yes, indicate the appropriate alternative below and explain how the process in question varies from the established method.

Class A: ☐ Alternative 1 ☐ Alternative 2
☐ Alternative 5__________________ ☐ Alternative 6 ____________________

Class B: ☐ Alternative 2 __________________ ☐ Alternative 3 ____________________

(For Class A Alternatives 5 and 6 and Class B Alternatives 2 and 3, list the specific Process to Further Reduce Pathogens (PFRP) or Process to Significantly Reduce Pathogens (PSRP))

Variation:

G. Operating Conditions: Provide a brief description of the specific process operating parameters that must be maintained to achieve consistent pathogen destruction. The description should include specific information on the physical, chemical, and biological requirements such as, temperature, pH, solids concentration, etc.

H. Performance: Provide average reductions recorded under the operating conditions described under Section G.

	Untreated Sludge	Treated Sludge	Reduction
Total Solids (%)			
Volatile Solids (%)			
Pathogens/Indicator:			
fecal coliform (MPN/g TS)*			
***Salmonella* sp.** (MPN/4g TS)			
enteric viruses (PFU/4g TS)			
***Ascaris* ova** (viable ova/4g TS)			
Other (include units):			

* CFU/g TS is allowable for PSRP equivalencies only. Check box if this substitution was made → ☐

I. Process Reliability: Provide a brief description of the uncontrolled conditions which affect the process's ability to achieve consistent and reliable results, such as, ambient temperatures and other weather conditions or environmental factors, sensitivity to loading variations, pH, chemicals which may be used upstream in the wastewater treatment process, etc.

J. Applications: Provide a brief description of the intended use of the sludge once treated. Include vector attraction reduction options, if applicable, advantages of this process, etc.

K. Full Application for Equivalency Recommendation: Attach a copy of the full application for equivalency recommendation.

L. Quality Assurance Project Plan (QAPP): Attach a copy of the approved QAPP. Any deviations from the QAPP must be documented either within the application or in a separate QAPP addendum provided here.

M. Analytical Results: Attach copies of the microbiological results for produced from fulfilling the QAPP. In addition, provide analytical results for the specific process operating parameters identified. All results must also be summarized in tabular form.

N. References: Provide a list of any literature cited or literature that would be useful in assessing the process itself and associated findings.

O. Certification: I hereby certify that the information and data contained in this application have been collected under the direction of the QAPP and are accurate.

NAME AND OFFICIAL TITLE (Use Corporate or Professional Seal As Appropriate):

Name: ____ **Title:** ___________________________________

Signature: ____

Telephone: (___)___-____ **Date Signed:** __/ __/ ____

Sworn and subscribed to before me:

This _________ day of _______________________________, 20 _________

____

Notary Public

(Notary Public Seal and Stamp)

United States Environmental Protection Agency
Pathogen Equivalency Committee

Pathogen Reduction Equivalency Application Package For Biosolids Treatment Processes

INSTRUCTIONS

Help With This Form

U.S. Pathogen Equivalency Committee Website

You can access the Pathogen Equivalency Committee website 7days a week, 24 hours a day at:

http://www.epa.gov/ORD/NRMRL/pec/

Many basic questions can be answered and guidance documents to assist in the successful completion of an equivalency application can be accessed by visiting the U.S. Pathogen Equivalency Committee website. This should be your first source of information for help in completing this form.

Contacting the U.S. Pathogen Equivalency Committee

You can communicate with the U.S. Pathogen Equivalency Committee (PEC) at your convenience through the PEC's e-mail address:

pec@epa.gov

If you are unable to find the information you are seeking, the PEC can be contacted by e-mail. If preferred, you may request to speak to a committee member by telephone. Simply indicate this preference in your e-mail and be sure to leave your phone number, days and time of availability and a brief description of your problem or question. A committee member would be happy to return your e-mail or set up a telephone call in a timely manner.

Before You Fill In This Form

Checklist of Prerequisites to This Form

☑ *Have you contacted your Permitting Authority?*

Your permitting authority should be the first point of contact on new applications for equivalency recommendation, especially if you are operating in conjunction with a specific treatment plant. You can identify your permitting authority through the State and Regional Coordinator Locator on the PEC website (http://www.epa.gov/ORD/NRMRL/pec/). All necessary contact information is provided.

☑ *Have you prepared a Quality Assurance Project Plan (QAPP)?**

A QAPP acts as a roadmap to successfully guide you through the collection of all necessary laboratory and field studies conducted in support of equivalency. See the Quality Assurance Project Plan page on the PEC website (http://www.epa.gov/ORD/NRMRL/pec/) for more information on the value of a QAPP and guidelines on how to develop one.

☑ *Has the Pathogen Equivalency Committee or Other Appropriate Authority Reviewed and Approved your QAPP?**

The PEC or other appropriate authority (such as your permitting authority or university) should have reviewed and approved your QAPP **before** any data is collected in support of this application for equivalency recommendation. The approved QAPP must be included in this package (see L. on the form) for reference and any deviations from the approved QAPP must be indicated.

☑ *Have you completed all necessary laboratory and field studies as detailed in your approved QAPP?**

Once your QAPP is approved it must be fulfilled. Unless documented with acceptable explanation, deviations from the approved QAPP will result in an incomplete equivalency application package.

*It is highly encouraged and greatly preferred that an applicant collect no data without operating under a QAPP or a similar type of document, other than preliminary proof-of-concept studies which are typically limited in scope. However, under some circumstances the Pathogen Equivalency Committee will accept applications in which all or some of the data presented was collected outside of a QAPP. In these cases, the data must still be collected using appropriate quality assurance and quality controls and the applicant must be able to provide the level of detail on required in the *Application Guidelines for Equivalency Recommendation* (see Line Instructions for K.) for the experimental approach, sampling and spiking procedures, analytical methods and quality assurance/quality control measures. These sections of the full application are typically roled over directly from the QAPP and are necessary to make an educated assessment on the equivalency of new/emerging sludge disinfection processes.

Letter Instructions For This Form

A. **Nature of Equivalency Request:** Check one (and only one) box in each column. For definitions of PSRP and PFRP visit the PEC website (http://www.epa.gov/ORD/NRMRL/pec/). Please note that the supporting data required for PSRP and PFRP equivalencies are different therefore the pathogen reduction type would have been selected prior to the development of the QAPP. The scope of equivalency, national versus site-specific, would also likely be reflected in the QAPP as a national equivalency may require additional data beyond that necessary for a site-specific equivalency recommendation. Thus, the boxes checked in this section are predetermined with the development and approval of the QAPP.

B. **Applicant Information:** Provide the name and contact information for the business, organization, or facility submitting this application package. Be sure to identify one individual as your contact person.

C. **Facility Information:** If the research conducted in this application package was completed in cooperation with a specific wastewater treatment plant or biosolids treatment facility, please provide the name and contact information, including a contact person, for this facility.

D. **Treatment Process Name:** Provide the full name of your treatment process, including any acronyms, trademarks, etc.

E. **Process Description:** Provide a concise description of your treatment process. All essential conditions necessary to achieve the required level of pathogen reduction should be included in your description. Noteworthy process design characteristics or unique components to the treatment process should also be included here. **Do not** include any information deemed confidential in this description. If a recommendation for equivalency is awarded, this description will be used by the Pathogen Equivalency Committee in their next revision of the White House Document and on their website on the Equivalent Processes page.

F. Comparison to Established Pathogen Reduction Processes: If your treatment process meets the operating conditions of an established pathogen reduction alternative under either Class A or B it should be indicated here. Descriptions of each alternative, as well as descriptions of specific processes under Class A Alternatives 5 & 6, and Class B Alternatives 2 & 3, can be found on the PEC website (http://www.epa.gov/ORD/NRMRL/pec/) under the White House Document page. In addition, recently recommended equivalent processes (i.e., processes which were awarded their equivalency after the most recent version of the white house document) can be found on the Equivalent Processes page. The variation(s) between your treatment process and the established alternative/process should be indicated.

> TIP *If you meet the operating conditions of an established alternative/ process without any variation, you do not need an equivalency recommendation for your process.*

G. Operating Conditions: Summarize the operating conditions of the key components of your treatment process under which consistent and reliable pathogen reduction can be expected.

H. Performance: Summarize the solids concentrations and the pathogen reductions observed during data collection under the operating conditions listed in Section G. **Do not** include any data taken outside these operating conditions. Arithmetic means should be used for the solids parameters and geometric means should be used for the organism densities. All numbers should be presented in the indicated units. The total solids denominator in the organism densities should be expressed as a dry weight basis. Fecal coliform density is the only parameter with some choice in units. When PSRP equivalency is sought regulations allow you to choose between the multiple tube fermentation and membrane filtration methods. If membrane filtration is used, CFU/g TS will be substituted for MPN/g TS and the check box should be checked. Otherwise, the default units of MPN/g TS will be applicable. Reductions for the solids should be left in percentages, but **reductions for the organism densities should be expressed in log transforms**.

I. Process Reliability: Any conditions which may affect the level of pathogen reduction achieved by your process should be listed here.

J. Applications: Provide a brief statement on the expected applications of the biosolids produced by your process. If you process itself concurrently meets a vector attraction reduction option, note which option as well as any special conditions that must be met to achieve vector attraction reduction concurrently to pathogen reduction. If your process does not achieve vector attraction reduction inherently, list which options may best be paired with your process. If you foresee any unique benefits to using you product for a particular application over biosolids produced with any other alternative/process, discuss it briefly here.

K. Full Application for Equivalency Recommendation: This section contains the real meat of the equivalency application package. The full application should contain a detailed account of the results from the laboratory and field studies laid out in the QAPP, all supporting information, and the rationale for receiveing a recommendation for equivalency from the PEC. Refer to the *Application Guidelines for Equivalency Recommendation* on the How to Apply page of the PEC website (http://www.epa.gov/ORD/NRMRL/pec/) for specific guidance on the develpoment of this document.

L. Quality Assurance Project Plan (QAPP): The QAPP provides an important foundation for any research project. Refer to the *QAPP Guidelines for Applied Research Projects* document found on the Quality Assurance Project Plan page of the PEC website (http://www.epa.gov/ORD/NRMRL/pec/) for specific guidance on the development of this plan. The QAPP must be included in the application package for reference and any deviations from the QAPP must be documented either within the application or in a separate QAPP addendum.

> TIP *The QAPP should be submitted to and approved by the PEC or other appropriate authority **prior to** the collection of data provided in the full application for equivalency. See the Checklist of Prerequisites to This Form*

M. Analytical Results: Provide copies of all results from the laboratory and field studies performed under the approved QAPP. Raw (i.e., unmanipulated) data is preferable here as the averaged or otherwise analyzed data be provided in the results section of your full application. Laboratory reports from a third party can be included. Data should be in order by date and all operating conditions or other measured parameters associated with the microbiological data should be clearly indicated. Quality assuance and quality control data, such as blanks and matrix spikes or recovery controls must also be included in this section.

N. **References:** A complete list of all literature cited must be included.

O. **Certification:** Certification is mandatory. This application package must be signed and notarized in order to be accepted for consideration by the PEC. This step is meant to deter falsification of data. An equivalency recommendation based on falsified data may have serious public health consequences and certification provide accountability.

Where and How to Submit Your Application Package

What to Submit

Once your application package is complete, submit the original Equivalency Application Package Form containing the notary public seal and all attachments detailed within, plus one complete copy of the entire package. Additional copies of the equivalency application package may be requested after the completeness of the package has been verified. A copy of the application package should also be submitted concurrently to your permitting authority. For contact information see the State and Regional Coordinator Locator on the PEC website (http://www.epa.gov/ORD/NRMRL/pec/).

Where to Submit

Send equivalency application packages to:

James E. Smith, Jr., PEC chair
U.S. Environmental Protection Agency
MS-421
26 West Martin Luther King Dr.
Cincinnati, OH 45268

What To Do Next

Be Patient! Obtaining a recommendation of equivalency requires a thorough examination of the process, which can be lengthy (3 or more months from the time the committee receives a completed application), but feel free to inquire on the progress of the review by contacting the Pathogen Equivalency Committee through their e-mail address: pec@epa.gov.

Appendix F

Practical Aspects for PFRP Equivalencies

Practical Aspects for PFRP Equivalencies

Over the last few decades the concentrations of naturally occurring enteric viruses and viable helminth ova routinely observed in raw sludge have dropped well below the levels necessary to demonstrate the required log reductions for the foundation of PFRP equivalency. While this is good news from a public health standpoint, it has been problematic for entities applying for PFRP equivalency. Remember, PFRP equivalency must demonstrate removal efficiencies not just compliance with 40CFR503 limits. When the untreated sludges used in PFRP equivalency testing are below 1,000 PFU per gram total solids (dry weight) of enteric viruses and/or 100 viable helminth ova per gram total solids (dry weight) one of two options is available:

Spiking

At the laboratory scale, spiking should not present much of a problem, however, at pilot or full-scale, appropriate spiking can be costly and difficult to carry out. In some cases, it may even be outright prohibited due to the potential health risks of an accidental release of pathogens. For these reasons, the PEC does not recommend use of this option for the purposes of demonstrating successful scale-up unless the spiking can be completed safely and effectively. If spiking is the preferred option, several issues must be addressed.

To determine the necessary number of organisms contained in the spike to ensure that the desired density of organisms in the untreated sludge is reached, it is recommended that a preliminary matrix spike be performed on the sludge to be used. At a minimum, the spike density must be calculated using a conservative (i.e., highest reasonable) percent solids concentration expected and a generous safety factor to account for sludge toxicity and analytical method recovery. Determining the appropriate spike density and volume is critical to a successful outcome. If the number of organisms recovered from the untreated sludge after spiking is not adequate to demonstrate the required log reductions, the effort and expense of the test will be wasted.

The applicant must document the source of the spiking organism, how it was collected and maintained, and how it was added to the untreated sludge.

The viability or titer of the spiking solution should be verified just prior to the actual spiking.

The spiked sludge must be assayed for the organisms of interest just prior to treatment. Estimates of the density of spiked organisms in the sludge based upon the number per unit volume of the organisms added to a given mass or volume of sludge is unacceptable.

Flow-through (typically continuously fed and completely mixed) treatment units present additional difficulty in ensuring that there is no short circuiting and that the spiked sludge is what is collected at the outfall. In these situations it is possible that any observed reduction in numbers can be attributed to, at least partially, dilution of the spiked sludges with unspiked sludges. Two suggested ways around this problem are adding a tracer to the spiked sludge and monitoring the tracer for dilution effects or extending the length of time over which the spike is added to greater than the calculated hydraulic residence time, then taking the treated samples following one full hydraulic residence time. Again, all conditions under which such experiments are performed must be specified and verified. It must be shown that measured log reductions are the result of treatment efficacy, not dilution.

Surrogates

This option may require some spiking of pathogens, but only at the laboratory-scale. Appropriate use of surrogates is shown in the table below. During laboratory-scale testing one or more additional organisms native to the untreated sludge used would be enumerated alongside of the spiked enteric viruses and/or helminth ova. In scale-up, the reduction of the surrogate organisms can be used along with the established relationships to helminth ova and/or enteric viruses to support successful scale-up and equivalency. It is currently not possible to identify one single surrogate organism that will work in all cases as the levels of naturally-occurring organisms will differ from location to location and relationships between organisms will differ depending on treatment. However, some examples of possible surrogates for helminth ova include aerobic endospores and Clostridium perfringens, while some examples of possible surrogates for enteric viruses include reoviruses and somatic bacteriophages. An appropriate surrogate must be identified on a case-by-case basis. Applicants are welcome to suggest other organisms as surrogates as long as data supporting the choice of surrogate is obtained for the sludge and treatment process under evaluation.

Appropriate Use of Surrogate Organisms				
	Enteric Virus Density in Feed Sludge		**Helminth Ova Density in Feed Sludge**	
	>1,000 PFU/4g TS	**≤1,000 PFU/4g TS**	**>100 ova/4g TS**	**≤100 ova/4g TS**
Laboratory-Scale Analysis	enteric viruses	seeded enteric viruses **and** somatic bacteriophages **or** reoviruses	helminth ova	seeded helminth ova **and** aerobic endospores **or** *Clostridium perfringens*
Full-Scale Analysis	enteric viruses	somatic bacteriophages **or** reoviruses	helminth ova	aerobic endospores **or** *Clostridium perfringens*

Appendix G

Commercial Laboratories with Pathogen Testing Capabilities

Commercial Laboratories with Pathogen Testing Capabilities

BioVir
685 Stone Road Unit #6
Benicia, California 94510
Tel: 707-747-5906
Tel: 800-442-7342
Fax: 707-747-1751
red@biovir.com

Environmental Associates
24 Oakbrook Drive
Ithaca, New York 14850-8717
Tel: 607-272-8902
Fax: 607-256-7092
eal-labs.com

HML
912 W. McGalliard
Muncie, Indiana 47303-1702
Tel: 765-288-1124
Fax: 765-288-8378
drh@hml.com

Aerotech
4645 E. Cotton Center Blvd, Building 3, Suite 189
Phoenix, Arizona 85040
Tel: 1-866-772-5227

Cost Estimates (per test)

TEST	PRICE
Salmonella	$200
Enteric Virus	$600
Viable Helminth Ova	$300
Total Solids	$35
Fecal Coliforms	$100

Appendix H

IEUA's Equivalency Application

Sylvie X

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

JAN 10 2002

December 21, 2001

Douglas D. Drury, PhD
Executive Manager of Operations
Inland Empire Utilities Agency
P.O. Box 697
Rancho Cucamonga, CA 91729

Dear Dr. Drury:

This is to approve your request of December 19, 2001 to use Class A Alternative 3 to demonstrate pathogen reduction. This process, which is site specific for IEUA Regional Plant Number 1, involves continuous flow to a three phase process: mesophilic acid digestion for 2 to 4 days at an average of about 96 degrees F, thermophilic gas digestion for 10 to 18 days at 122 to 125 degrees F, and an unheated phase of 4 to 7 days with temperatures ranging from 113 to 121 degrees F. The approval is based on the data collected between March and November 2001 showing non-detectable levels of fecal coliform, enteric viruses, and helminth ova in the final biosolids when the thermophilic phase is run at temperatures in the range of 50.5 to 53 degrees for times in the range of 12 to 15 days (weekly averages).

The following minimum operating parameters must be met:

1. A minimum HRT of 2 days, monthly average, in the first phase (mesophilic acid digestion).

2. A minimum HRT of 14 days, monthly average, in the second phase (thermophilic digestion)

3. A minimum HRT of 10 days, daily minimum, in the second phase

3. The temperature in the second phase shall be set for 125 degrees F, and not allowed to go below 122 degrees F.

4. A minimum HRT of 4 days, monthly average, in the third phase.

The following pathogen limits must be met:

1. Fecal coliform in the digested biosolids shall be monitored on a weekly basis. The fecal coliform concentration shall be less than 1,000 MPN per gram total solids.

2. Enteric viruses in the digested biosolids shall be monitored once per month. The enteric virus concentration shall be less than one plaque forming unit per 4 grams total solids.

3. Helminth ova shall be monitored on a monthly basis. Every other month, samples shall be collected prior to digestion, and in the other months, after digestion. The viable helminth ova concentration either before or after digestion shall be less than one per 4 grams total solids.

Please call me at (415) 972-3514 with any questions on this.

Sincerely,

Lauren V. Fondahl
Biosolids Coordinator
Clean Water Act Compliance Office
EPA Region 9

December 19, 2001

Lauren Fondahl
U.S. EPA Region IX
Biosolids Coordinator
Office of Clean Water Act Compliance
75 Hawthorne Street
San Francisco, CA 94105-3901

Re: Class A approval for Continuous Feed Three-Phase Thermophilic Digestion

Dear Ms. Fondahl:

Inland Empire Utilities Agency (IEUA) hereby requests your approval for the continuous feed three-phase thermophilic digestion to be approved as a site-specific process that produces class A sludge, using Alternative 3 of 40 CFR Part 503.

Since March 2001, IEUA has successfully demonstrated that its use of the three phase thermophilic digestion has resulted in consistent production of biosolids that meets or exceeds the requirements for Class A, based on Alternative 3 of 40 CFR Part 503. The dewatered biosolids from the three-phase digestion have consistently produced fecal coliform concentrations less than the detection limit of 11 MPN/gram TS (36 of 42 non-detects between March and December, 2001). *Salmonella* and enteric viruses, each exhibited a 1-log removal and 2-log removal, respectively. Since helminth ova were not detected in either the thickened primary sludge or the dewatered biosolids, it is difficult to demonstrate log removals. Please refer to the attached report for detailed information on the operational parameters and test results for coliform and pathogens.

Based on the results achieved, IEUA would like to obtain approval from the EPA for the continuous feed three-phase thermophilic digestion to be approved as a site-specific process that produces Class A biosolids, given that the following process and monitoring requirements are met.

Process Requirements

It is proposed that the following operating parameters be maintained for the process to meet the Class A requirements:

1. Maintain a minimum hydraulic retention time (HRT) of 10 days in the second phase thermophilic digesters.
2. Maintain a minimum HRT of 4 days in the third phase thermophilic/mesophilic digesters.
3. Maintain a minimum temperature of 50°C (122°F) in the second phase thermophilic digesters.
4. The fecal coliform concentration, in the dewatered biosolids, should be less than 1,000 MPN per g per total solids.

Monitoring Requirements

It is proposed that the following monitoring frequency be met to determine compliance with the Class A requirements:

1. The temperature at the digesters should be monitored daily, on a continuous basis.
2. The dewatered biosolids from RP-1 should be monitored for fecal coliform once per week.
3. Thickened primary sludge and the dewatered biosolids should be monitored for coliform and pathogens (helminth ova, *Salmonella*, and enteric viruses) once per month.

IEUA is currently monitoring the dewatered biosolids from RP-1 weekly for fecal coliform, and once a month for pathogens. IEUA will continue with the current monitoring frequency until we receive comments from the EPA. We believe that the continuous feed three-phase digestion process configuration produces biosolids that meets or exceeds the requirements set forth in 40 CFR Part 503 regulations.

In the meantime, we will also evaluate the feed/hold/draw semi-batch system, on one of the process trains, at thermophilic temperatures, lower than 50°C. We look forward to hearing from you and discussing any additional information you may need. If you have any questions or comments, please call me at (909) 947-4131.

Sincerely,

Douglas D. Drury, PhD
Executive Manager of Operations

Attachment: Report: Class A Approval for Three Phase Thermophilic Digestion

cc: Dr. Jim Smith
Senior Environmental Engineer and PEC Chair
U.S. EPA – NRMRL – TTSD
26 W Martin Luther King Drive
Cincinnati, OH 45268

Inland Empire Utilities Agency

Class A approval for Continuous Feed Three-Phase Thermophilic Digestion

Inland Empire Utilities Agency (IEUA) presently owns and operates four treatment plants in southwest San Bernardino County in California. Regional Water Reclamation Plant No. 1 (RP-1), located in Ontario, has a treatment capacity of 44 MGD and Regional Water Reclamation Plant No.4 (RP-4), located in Ranch Cucamonga, has a treatment capacity of 7 MGD. Sludge produced at RP-1 and RP-4 is processed at RP-1. Sludge processed at RP-1 is a combination of approximately 60% primary and 40% waste activated sludge. RP-1 was originally designed to treat sludge anaerobically with seven single stage digesters (for digester specifications, refer to Appendix, Table I.) The facility solids handling capacity can be achieved with one digester out of service for cleaning or repair.

THREE-PHASE THERMOPHILIC DIGESTION

IEUA currently uses six of the seven digesters for the three-phase thermophilic digestion. The system comprises of three parallel anaerobic digestion systems, each of which uses three-phase thermophilic digestion. These digesters are operated in the process configuration shown in Figure 1. The first phase is a mesophilic acid digester, operated within the temperature range of 32°C to 40°C. The second phase is a thermophilic gas digester, operating within the range of 50°C to 56°C. No heat is added to the third phase. Therefore, the temperatures of the third phase gas digesters fluctuate between 42°C to 49°C, depending on the ambient temperature.

FECAL COLIFORM TEST RESULTS

IEUA started up the three-phase thermophilic digestion in November 2000, and achieved desired temperature settings and process stability by March 20, 2001. IEUA used both cow manure and anaerobically digested mesophilic sludge to seed the new thermophilic digester. The second phase thermophilic digesters, 6 and 7, have been operated in a 50°C continuous-feed mode since start-up in November 2000. Since late March 2001, these two process trains have consistently produced fecal coliform concentrations less than the detection limit (11 MPN/gram TS). In fact, between March and December 2001, the three-phase 50°C continuous-feed digestion system produced 36 of 42 "non-detects" for the fecal coliform test (Appendix, Tables II, III). Digester 2 was operated in the same mode from April through August 2^{nd}. On August 2, 2001, digester 2 was converted to operate in a semi-batch mode. Coliform data for the period of June and July 2001 for digester 2 is also presented in the Appendix, Table II.

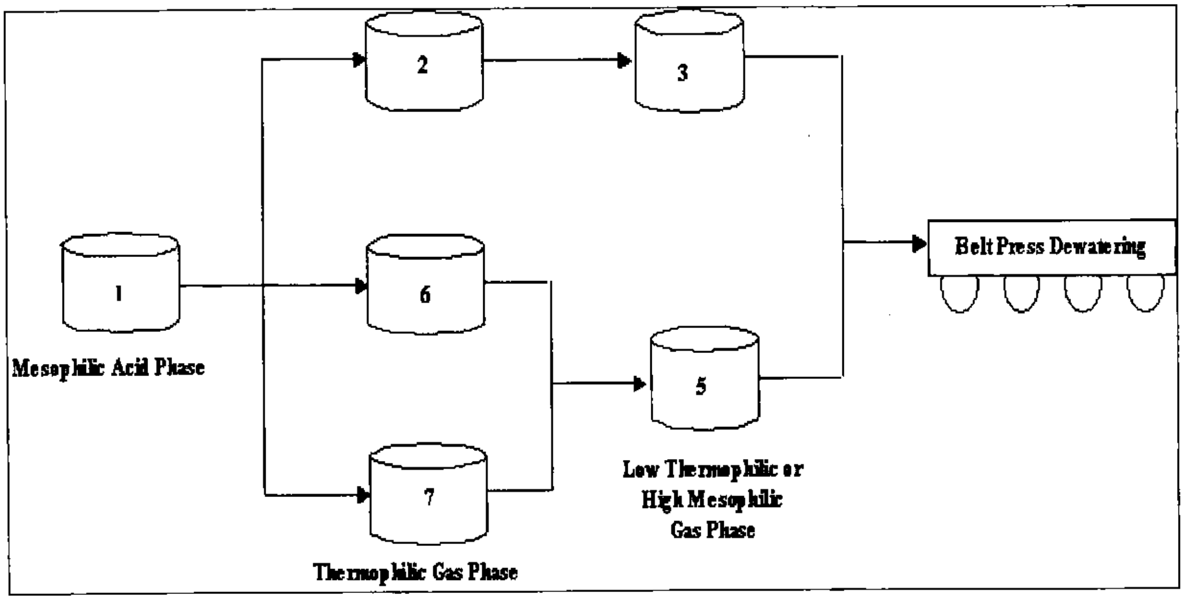


FIGURE 1
Three Phase Process Diagram at Regional Plant No. 1

PATHOGEN TEST RESULTS

During the third week in June 2001, IEUA began temporarily storing the dewatered sludge in its drying beds because alternative disposal options were not available. At the same time, IEUA began its investigation on other methods to produce Class A biosolids to increase its sludge disposal options. Since the fecal coliform concentrations from the three phase 50°C continuous feed digestion system were consistently "non-detects", it was believed that the biosolids would meet the Class A requirements for helminth ova, enteric virus, and *Salmonella*. IEUA immediately started testing the biosolids in the drying beds for the three pathogens to determine if the sludge would meet the Class A requirements of 40 CFR Part 503 using Alternative 4. In addition, analysis of the thickened primary sludge was conducted for the three pathogens. The time to receive results of the pathogen analysis can be as much as 8 weeks, due to the nature of the analysis. Between June and October, 2001, fifteen (15) samples of the biosolids treated by three phase 50°C continuous feed digestion system were analyzed for the pathogens; helminth ova, enteric virus and *Salmonella*. No pathogens were found in the treated biosolids. With these results, IEUA certified the stored biosolids in the drying beds as Class A using Alternative 4.

Between June and October 2001, six (6) samples of the thickened primary sludge were also analyzed for the pathogens. The results of the pathogen tests for the raw sludge and treated biosolids are shown in Figure 2. Two log removals for enteric viruses, and one log removal for *Salmonella* was demonstrated with the three-phase digestion process (Appendix, Table IV). Helminth ova were not found in the raw sludge. Since helminth ova were also not found in the treated biosolids, it is difficult to demonstrate levels of removals.

It should be noted that of the six samples of the thickened primary sludge that was analyzed, five of them were non-detect with respect to helminth ova. For the sample collected on September 10, 2001, the contracted laboratory could not perform helminth ova analysis due to matrix interference from biological mass. During sample preparation for the helminth ova analysis, solids are blended with buffered water. Solids are allowed to settle, after which the supernatant is poured off and the solids are subjected to a density gradient centrifugation. Usually different layers are obtained and the ova, if present, separated from the rest of the biological mass. For this particular instance, the separation did not occur, and the test could not be completed. The plausible cause for this instance might be the presence of polymers and other substances that did not allow the ova to separate.

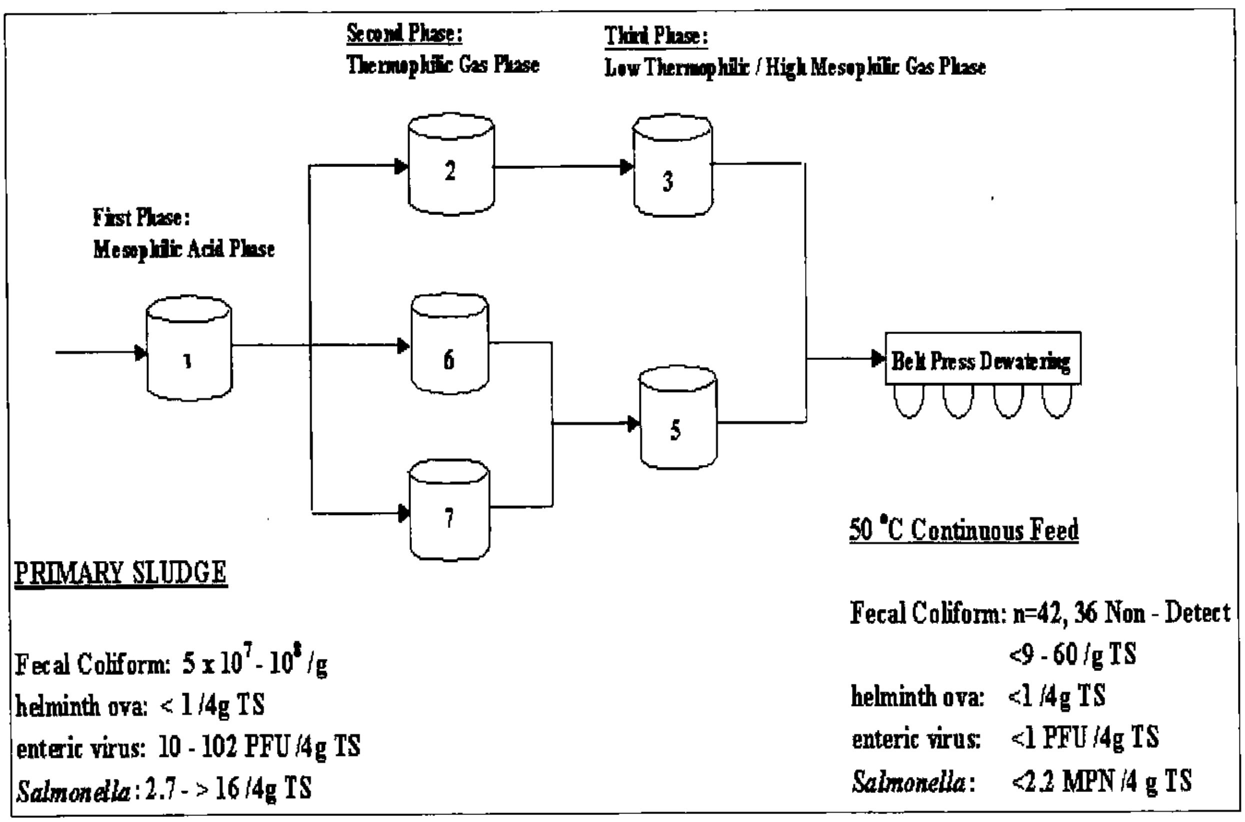


FIGURE 2:
Three Phase Digestion: Pathogen Test Results

PROCESS PARAMETERS

An overview of the important operational parameters is summarized in Table 1. The first phase acid digester has a hydraulic residence time (HRT) ranging between 2.2 and 6 days, which is longer than the traditional HRT of 1-1.5 days of most acid digesters. A pH of 5.1 to 5.3 was still maintained at the acid phase digester even with the longer HRTs.

The pH in all of the second and third phase digesters was similar, ranging from 7.5 to 8.0. The second phase thermophilic digester has an HRT ranging between 10.6 and 29 days and the third phase mesophilic digester has an HRT ranging between 3.9 and 10.9 days. The shorter detention time in the third phase was more than adequate to treat the 130 to 480 mg/l of volatile acids entering that stage. For a complete data set summarizing the operational parameters, refer to Appendix, Table V.

2001	Mesophilic Acid		Mesophilic Gas		Thermophilic Gas			
	Digester #1		Digester #5		Digester #6		Digester #7	
	Temp °C	HRT days	Temp °C	HRT days	Temp °C	HRT Days	Temp °C	HRT days
April	32.2	3.4	47.5	6.0	51.2	16.2	52.6	16.3
May	32.3	3.1	48.8	5.6	52.4	15.2	53.8	15.2
June	33.9	2.9	48.2	5.3	50.4	14.3	51.4	14.4
July	37.3	3.1	48.1	5.4	51.0	14.7	51.3	14.7
August	39.5	3.3	48.9	5.9	50.6	16.0	51.1	16.1
September	39.3	3.4	48.6	6.2	50.9	16.7	50.9	16.8
October	39.0	3.0	48.2	5.4	50.9	14.4	50.9	14.4
November	38.9	3.0	48.2	5.2	50.6	13.8	50.7	13.9
Average	**36.5**	**3.2**	**48.3**	**5.6**	**51.0**	**15.2**	**51.6**	**15.2**

TABLE 1:
Typical Operating Parameters for Three Phase Thermophilic Digestion

Odors, which are traditionally associated with thermophilic digestion, seem to be correlated to high volatile acids and other odorous compounds such as dimethyl sulfides. Several different parameters are used to monitor the production and degradation of volatile acids. IEUA selected the IA:PA ratio (Intermediate Alkalinity: Partial Alkalinity). The IA:PA ratio is defined as:

$$\frac{\textbf{IA (Alkalinity between pH 5.75 and 4.3)}}{\textbf{PA (Alkalinity down to pH of 5.75)}}$$

The ratio of IA:PA is analogous to VA:Alk ratio (Volatile Acids : Alkalinity) and is a parameter used to monitor the stability of the anaerobic digestion process. This approach is simple and inexpensive, and yet sensitive to process changes. In general, the higher the volatile acid concentration, the higher the IA:PA ratio. A stable anaerobic digester producing a well treated biosolids would have an IA:PA of about 0.3.

Digester 2, which is also operated as a thermophilic gas digester, consistently had an IA:PA ratio of 0.3. However, in August 2001 when the temperature of digester 2 was raised to 135°F, the IA:PA ratio also increased. At the higher temperatures, the IA:PA ratio increased to about 0.8. The increase in IA:PA was due to the increased concentrations of volatile acids in digester 2. The largest individual volatile acid was propionic acid. Isobutyric and isovaleric acids also increased with increasing temperatures. Propionic, isobutyric, and isovaleric are all odor-causing chemicals.

Dimethyl sulfides are also known to be odor-producing compounds. Volatile analysis was performed on the two digesters. The results indicate the presence of dimethyl sulfides when the temperature in the thermophilic digester reached 56°C. There were no dimethyl sulfides present in the 50°C second phase thermophilic digesters 6 and 7.

CONCLUSION

Since March 2001, IEUA has successfully demonstrated that its use of the three-phase thermophilic digestion has resulted in consistent production of biosolids that meets or exceeds the requirements for class A, based on Alternative 3 of 40 CFR Part 503. Therefore, IEUA would like EPA to approve the three-phase thermophilic digestion as a process that produces class A biosolids, given that the following process and monitoring requirements are met:

Process Requirements

It is proposed that the following operating parameters be maintained for the process to meet the Class A requirements:

1. Maintain a minimum hydraulic retention time (HRT) of 10 days in the second phase thermophilic digesters.
2. Maintain a minimum HRTof 4 days in the third phase thermophilic/mesophilic digesters.
3. Maintain a minimum temperature of 50°C (122°F) in the second phase thermophilic digesters. The temperature should be monitored on a continuous basis.
4. The fecal coliform concentration, in the dewatered biosolids, should be less than 1,000 MPN per g per total solids.

Monitoring Requirements

It is proposed that the following monitoring frequency be used to determine compliance with the Class A requirements:

1. The dewatered biosolids from RP-1 should be monitored for fecal coliform once per week.
2. Thickened primary sludge and the dewatered biosolids should be monitored for coliform and pathogens (helminth ova, *salmonella*, and enteric viruses) once per month.

APPENDIX

TABLE I: Digester Specifications

Digester No	Diameter (ft)	Height (ft)	Volume (ft^3)
1	69	30	122,487
2	69	30	122,487
3	65	30	113,318
4	65	30	113,318
5	80	30	167,467
6	90	30	224,667
7	90	30	224,667

TABLE II: Dewatered Biosolids: Fecal Coliform Analysis

Date of Sample	*Fecal (MPN/100 mL):*	*Fecal Coliforms per g TS*	*Digester:*	*% TS:*	*Duplicate*
Mar 20, 01	<200	**<11**	Dig 5	18.8	
Mar 20, 01	<200	**<11**	Dig 5	18.8	
Mar 27, 01	<200	**<9**	Dig 5	21.3	
Apr 10, 01	<200	**<10**	Dig 5	20.0	
Apr 17, 01	<200	**<11**	Dig 5	18.6	
Apr 17, 01	<200	**<11**	Dig 5	18.6	
Apr 24, 01	200	**10**	Dig 5	19.9	
May 08, 01	<200	**<11**	Dig 5	17.6	QC Failure
May 15, 01	<200	**<10**	Dig 5	19.8	
May 15, 01	<200	**<10**	Dig 5	19.8	
May 22, 01	<200	**<10**	Dig 5	20.6	
May 29, 01	<200	**<10**	Dig 5	19.2	
May 29, 01	<200	**<10**	Dig 5	19.2	
Jun 05, 01	200	**10**	Dig 3	19.7	
Jun 12, 01	200	**11**	Dig 3	17.6	
Jun 12, 01	<100	**<11**	Dig 3	17.6	
Jun 14, 01	<200	**<10**	Dig 5	19.1	
Jun 14, 01	<200	**<10**	Dig 3	20.1	
Jun 14, 01	<200	**<10**	Dig 3	20.1	
Jun 19, 01	<200	**<10**	Dig 5	20.1	
Jun 20, 01	<200	**<10**	Dig 3	19.1	
Jun 20, 01	<200	**<10**	Dig 5	19.8	
Jun 26, 01	<200	**<11**	Dig 3	18.2	
Jun 26, 01	<200	**<11**	Dig 3	18.2	
Jun 27, 01	<200	**<11**	Dig 5	18.0	
Jun 27, 01	<200	**<11**	Dig 3	18.5	
Jul 05, 01	<200	**<10**	Dig 5	19.5	
Jul 10, 01	<200	**<11**	Dig 3	18.4	
Jul 10, 01	<200	**<11**	Dig 3	18.4	
Jul 17, 01	400	**22**	Dig 3	18.4	
Jul 24, 01	<200	**<11**	Dig 5	18.2	
Jul 24, 01	<200	**<11**	Dig 5	18.2	
Jul 31, 01	<200	**<10**	Dig 5	19.9	
Aug 07, 01	200	**10**	Dig 5	19.5	
Aug 07, 01	<200	**<10**	Dig 5	19.5	
Aug 14, 01	<200	**<9**	Dig 5	21.3	
Aug 28, 01	<200	**<9**	Dig 5	21.2	
Sep 11, 01	<200	**<10**	Dig 5	20.9	QC Failure
Sep 25, 01	<200	**<10**	Dig 5	20.2	
Oct 09, 01	<200	**<10**	Dig 5	20.7	
Oct 23, 01	<200	**<10**	Dig 5	21.1	
Nov 06, 01	<200	**<10**	Dig 5	20.7	
Nov 20, 01	<200	**<10**	Dig 5	21.0	
Dec 04, 01	1300	**60**	Dig 5	21.6	

TABLE III: Thickened Primary Sludge: Fecal Coliform Analysis

Date of Sample	*Fecal (MPN/100 mL):*	*Fecal Coliforms/g TS*	*Digester:*	*% TS:*
Jun 14, 01	900,000,000	**179,000,000**	Gravity	5.03
Jun 14, 01	500,000,000	**99,400,000**	Gravity	5.03
Jun 14, 01	400,000,000	**79,000,000**	Gravity	5.03
Jun 20, 01	900,000,000	**250,000,000**	Gravity	3.61
Jun 20, 01	500,000,000	**140,000,000**	Gravity	3.61
Jun 20, 01	200,000,000	**55,500,000**	Gravity	3.61
Jun 27, 01	900,000,000	**189,000,000**	Gravity	4.76
Jun 27, 01	300,000,000	**63,000,000**	Gravity	4.76
Jun 27, 01	270,000,000	**56,700,000**	Gravity	4.76

TABLE IV: Pathogen Analysis

Sample Date	*Thickened Primary Sludge* Helminth Ova per 4 g TS	*Thickened Primary Sludge* Enteric Virus PFU / 4 g TS	*Thickened Primary Sludge* Salmonella MPN / 4 g TS	*Digester Dewatered Biosolids* Helminth Ova per 4 g TS	*Digester Dewatered Biosolids* Enteric Virus PFU / 4 g TS	*Digester Dewatered Biosolids* Salmonella MPN / 4 g TS
6/14/2001	<1	102	9.2	<1	<1	<2.2
6/14/2001	NS			<1	<1	<2.2
6/20/2001	<1	36	16	<1	<1	<2.2
6/20/2001	NS			<1	<1	<2.2
6/27/2001	<1	46	>16	<1	<1	<2.2
6/27/2001	NS			<1	<1	<2.2
7/5/2001	NS			<1	<1	<2.2
7/10/2001	NS			<1	<1	<2.2
7/17/2001	NS			<1	<1	<2.2
7/24/2001	NS			<1	<1	<2.2
7/30/2001	NS			<1	<1	<2.2
8/20/2001	NS			<1	<1	NA
9/10/2001	**	58	16	<1	<1	<2.2
10/8/2001	NS			<1	<1	<2.2
10/9/2001	<1	18	2.7	NS		
10/22/2001	NS			<1	<1	<2.2
11/5/2001	<1	10	>16	NS		
Max	**<1**	**102**	**>16**	**<1**	**<1**	**<2.2**
Avg	**<1**	**52**	**12**	**<1**	**<1**	**<2.2**
Min	**<1**	**10**	**2.7**	**<1**	**<1**	**<2.2**

NA Not Analyzed:
Sample could not be analyzed because the holding time for the sample was exceeded (Fed-Ex delivery was delayed)

NS No Sample

** Matrix Inteference with biomass growth; Sample could not be analyzed

TABLE V: Operational & Process Parameters

April	Digester No. 1				Digester No. 5			Digester No. 6			Digester No. 7		
2001	Sludge Primary Kgal/d	Sludge WAS Kgal/d	Temp °F	HRT days	Sludge From #6&#7 Kgal/d	Temp °F	HRT days	Sludge From #1 Kgal/d	Temp °F	HRT days	Sludge From #1 Kgal/d	Temp °F	HRT days
1	130	92	91.0	3.5	177.8	119.5	6.7	88.9	127.4	17.8	88.9	127.0	17.9
2	171	95	89.2	2.9	212.5	118.0	5.4	106.2	127.9	14.5	106.2	128.0	14.6
3	164	91	90.8	3.1	204.2	120.0	5.7	102.1	127.2	15.3	102.1	127.7	15.3
4	164	91	89.6	3.0	204.5	109.0	5.6	102.3	127.2	15.0	102.3	128.5	15.1
5	150	84	90.7	3.3	187.7	105.0	6.2	93.8	126.8	16.5	93.8	128.4	16.5
6	144	83	90.1	3.4	181.5	118.0	6.4	90.7	126.4	17.2	90.7	129.0	17.3
7	150	78	89.7	3.4	182.8	119.0	6.3	91.4	126.6	16.8	91.4	129.2	16.9
8	142	78	90.0	3.5	176.4	119.0	6.4	88.2	126.6	17.1	88.2	128.6	17.2
9	137	86	90.3	3.5	178.5	119.0	6.2	89.3	126.2	16.6	89.3	128.8	16.7
10	164	82	90.3	3.2	197.2		5.6	98.6	125.9	15.2	98.6	128.0	15.2
11	150	76	89.1	3.4	181.2	119.0	6.1	90.6	125.4	16.5	90.6	128.2	16.6
12	155	74	91.0	3.4	182.9	118.0	6.1	91.4	124.9	16.3	91.4	127.9	16.4
13	123	71	88.9	4.0	155.3	118.0	7.1	77.6	125.0	19.2	77.6	128.2	19.2
14	123	63	89.9	4.2	148.8		7.4	74.4	125.3	19.9	74.4	128.6	20.0
15	144	68	89.6	3.7	169.3	119.0	6.3	84.6	124.9	17.3	84.6	128.7	17.4
16	150	73	89.4	3.5	179.1		6.2	89.6	124.6	16.5	89.6	127.8	16.5
17	160	77	90.4	3.3	189.7	119.0	5.8	94.9	124.5	15.8	94.9	127.8	15.9
18	178	76	88.7	3.1	202.9	124.8	5.5	101.4	124.8	14.6	101.4	128.4	14.6
19	178	66	89.9	3.2	195.2	119.0	5.6	97.6	124.3	14.9	97.6	127.9	14.9
20	178	76	90.0	3.1	203.4	118.0	5.4	101.7	123.2	14.5	101.7	126.0	14.6
21	164	68	89.8	3.4	185.6	120.0	6.0	92.8	121.6	16.0	92.8	123.3	16.0
22	157	86	90.0	3.2	194.8	116.5	5.7	97.4	120.2	15.3	97.4	122.9	15.4
23	164	80	90.3	3.2	195.2	114.0	5.6	97.6	118.9	15.1	97.6	121.6	15.2
24	171	85	90.5	3.0	204.6	117.0	5.4	102.3	119.2	14.5	102.3	122.2	14.5
25	171	87	89.1	3.0	206.3	118.0	5.3	103.2	120.3	14.4	103.2	123.2	14.4
26	164	69	90.2	3.3	186.7	117.0	5.9	93.4	120.7	15.8	93.4	123.7	15.8
27	157	70	89.5	3.4	182.1	117.0	6.1	91.1	121.6	16.3	91.1	124.4	16.4
28	144	64	90.2	3.7	165.7	117.0	6.8	82.9	122.2	18.2	82.9	125.2	18.2
29	144	75	89.3	3.6	174.6		6.2	87.3	122.5	17.1	87.3	126.2	17.2
30	150	81	88.9	3.4	185.1		6.1	92.5	121.5	16.3	92.5	125.3	16.3
Max	**178**	**95**	**91.0**	**4.2**	**212.5**	**124.8**	**7.4**	**106.2**	**127.9**	**19.9**	**106.2**	**129.2**	**20.0**
Avg	**155**	**78**	**89.9**	**3.4**	**186.4**	**117.5**	**6.0**	**93.2**	**124.1**	**16.2**	**93.2**	**126.7**	**16.3**
Min	**123**	**63**	**88.7**	**2.9**	**148.8**	**105.0**	**5.3**	**74.4**	**118.9**	**14.4**	**74.4**	**121.6**	**14.4**

Note:

Kgal/day: Kilo gallons per day
WAS: Waste Activated Sludge
HRT: Hydraulic Retention Time

Digester No.1: First Phase Mesophilic
Digester No.5: Third Phase Mesophilic
Digester No. 6 & 7: Second Phase Thermophilic

Blank Space: Data Not Available

TABLE V: Operational & Process Parameters (Contd.)

May	Dig #1				Dig #5			Dig #6			Dig #7		
2001	Sludge Primary Kgal/d	Sludge WAS Kgal/d	Temp °F	HRT days	Sludge From #6&#7 Kgal/d	Temp °F	HRT days	Sludge From #1 Kgal/d	Temp °F	HRT days	Sludge From #1 Kgal/d	Temp °F	HRT days
1	150	78	93.0	3.4	182.4		6.1	91.2	122.6	16.4	91.2	125.8	16.5
2	179	73	89.2	3.1	201.8	117.0	5.5	100.9	124.0	15.0	100.9	128.0	15.1
3	192	73	91.4	2.9	212.0	117.0	5.3	106.0	125.3	14.3	106.0	129.0	14.3
4	150	87	89.4	3.3	189.8	118.0	5.9	94.9	126.0	15.8	94.9	129.3	15.9
5	144	62	89.7	3.8	164.6	126.2	6.8	82.3	126.2	18.3	82.3	129.9	18.3
6	137	80	89.7	3.6	173.7	120.0	6.4	86.9	127.3	17.2	86.9	130.8	17.4
7	137	81	89.2	3.6	174.4	119.0	6.3	87.2	128.1	17.1	87.2	131.7	17.2
8	137	99	90.6	3.3	188.6	120.0	5.8	94.3	128.6	15.7	94.3	132.4	15.7
9	178	91	91.9	2.9	215.2		5.1	107.6	129.0	13.8	107.6	130.1	13.8
10	150	88	89.3	3.3	190.8	121.0	5.8	95.4	129.5	15.6	95.4	128.8	15.7
11	150	80	90.3	3.4	184.1	120.0	6.1	92.0	128.9	16.3	92.0	129.5	16.3
12	144	71	89.0	3.6	171.4	121.0	6.4	85.7	129.0	17.7	85.7	130.0	17.7
13	142	71	91.1	3.6	170.5		6.5	85.3	128.6	17.6	85.3	130.0	17.8
14	164	63	90.1	3.4	182.1	120.0	6.0	91.0	128.6	16.1	91.0	130.5	16.2
15	164	70	90.3	3.3	186.9		5.7	93.5	128.5	15.7	93.5	130.6	15.7
16	150	70	89.4	3.5	176.1	120.0	6.2	88.0	128.2	16.5	88.0	130.1	16.5
17	171	65	90.3	3.3	188.6		5.8	94.3	128.0	15.7	94.3	130.2	15.7
18	192	64	89.7	3.0	204.5	121.0	5.5	102.3	128.2	14.7	102.3	130.2	14.8
19	178	59	89.9	3.3	189.8	122.0	5.9	94.9	127.6	15.9	94.9	129.4	16.0
20	150	74	90.1	3.5	179.9		6.3	89.9	126.9	16.9	89.9	129.1	17.0
21	192	78	90.0	2.9	215.5	122.0	5.2	107.7	127.0	13.8	107.7	129.2	13.8
22	198	90	90.4	2.7	230.4	121.0	4.7	115.2	126.6	12.9	115.2	128.6	12.9
23	185	102	90.1	2.7	229.7	122.0	4.8	114.8	126.0	12.9	114.8	128.7	12.9
24	185	99	89.8	2.7	226.7	120.0	5.0	113.3	125.7	13.3	113.3	128.6	13.4
25	185	90	91.1	2.8	219.4	119.0	5.2	109.7	124.6	13.8	109.7	127.2	13.8
26	185	97	89.3	2.8	225.7	122.0	5.0	112.8	124.0	13.5	112.8	127.0	13.6
27	171	111	91.3	2.7	225.9	116.0	5.0	113.0	122.2	13.3	113.0	126.2	13.4
28	157	93	89.2	3.1	200.6	122.0	5.6	100.3	123.0	15.1	100.3	126.0	15.1
29	198	117	89.0	2.5	252.3	121.5	4.7	126.1	123.0	12.5	126.1	126.2	12.5
30	192	99	91.2	2.7	232.2	119.5	5.1	116.1	122.5	13.6	116.1	125.9	13.6
31	198	93	89.8	2.7	233.4	111.0	5.1	116.7	121.9	13.7	116.7	126.2	13.8
Max	**198**	**117**	**93.0**	**3.8**	**252.3**	**126.2**	**6.8**	**126.1**	**129.5**	**18.3**	**126.1**	**132.4**	**18.3**
Avg	**168**	**83**	**90.2**	**3.1**	**200.6**	**119.9**	**5.6**	**100.3**	**126.3**	**15.2**	**100.3**	**128.9**	**15.2**
Min	**137**	**59**	**89.0**	**2.5**	**164.6**	**111.0**	**4.7**	**82.3**	**121.9**	**12.5**	**82.3**	**125.8**	**12.5**

Note:

Kgal/day: Kilo gallons per day
WAS: Waste Activated Sludge
HRT: Hydraulic Retention Time

Digester No.1: First Phase Mesophilic
Digester No.5: Third Phase Mesophilic
Digester No. 6 & 7: Second Phase Thermophilic

Blank Space: Data Not Available

TABLE V: Operational & Process Parameters (Contd.)

June	Dig #1				Dig #2		Dig #3		Dig #5			Dig #6			Dig #7		
2001	Sludge Primary Kgal/d	Sludge WAS Kgal/d	Temp °F	HRT days	Temp °F	Det. Time days	Temp °F	Det. Time days	Sludge From #6&#7 Kgal/d	Temp °F	HRT days	Sludge From #1 Kgal/d	Temp °F	HRT days	Sludge From #1 Kgal/d	Temp °F	HRT days
1	171	88	90.4	3.0	121.6	16.1	110.7	15.0	207.1	119.5	5.6	103.6	122.7	15.0	103.6	125.9	15.2
2	157	96	91.0	3.1	122.6	16.3	111.2	15.3	202.4	119.5	5.7	101.2	123.5	15.2	101.2	127.3	15.2
3	171	105	90.4	2.8	122.1	14.4	111.4	13.6	220.5	120.0	5.1	110.3	123.4	13.9	110.3	125.9	13.9
4	192	101	90.1	2.7	122.0	13.8	111.1	13.0	233.6	115.0	4.8	116.8	122.8	13.0	116.8	123.7	13.0
5	192	107	89.3	2.6	121.9	14.0	110.3	13.2	238.6	121.0	4.7	119.3	122.5	12.9	119.3	120.2	12.9
6	192	106	91.0	2.6	121.1	14.3	110.2	13.3	238.0	116.5	4.8	119.0	121.7	12.9	119.0	120.4	13.0
7	171	116	91.2	2.7	120.7	14.3	111.1	13.5	229.4	117.0	5.1	114.7	122.0	13.6	114.7	120.8	13.7
8	150	97	89.5	3.2	122.7	16.6	111.0	15.5	198.0	118.0	5.8	99.0	122.0	15.6	99.0	123.1	15.6
9	137	75	89.9	3.7	123.5	18.6	112.3	17.6	169.5		6.7	84.8	123.1	18.1	84.8	124.9	18.2
10	164	98	90.8	3.0	120.7	15.6	111.7	14.6	209.6	120.0	5.4	104.8	123.8	14.4	104.8	127.1	14.5
11	178	95	90.3	2.9	122.9	14.6	112.2	13.8	218.3	116.0	5.2	109.1	123.4	14.0	109.1	126.3	14.1
12	172	106	89.2	2.8	123.5	15.0	112.0	14.0	223.0		5.0	111.5	123.9	13.9	111.5	125.9	14.0
13	192	88	90.0	2.8	123.2	14.6	111.9	13.8	223.8	115.0	5.0	111.9	123.9	13.6	111.9	126.1	13.7
14	164	100	89.9	3.0	123.1	15.6	112.0	14.6	210.9	121.0	5.3	105.5	123.0	14.4	105.5	126.3	14.4
15	144	101	89.9	3.2	123.5	16.3	113.1	15.4	195.8	120.0	5.7	97.9	123.7	15.7	97.9	126.2	15.8
16	164	86	90.3	3.1	124.6	15.7	113.3	14.8	200.1	121.0	5.3	100.1	124.0	14.8	100.1	125.8	14.9
17	171	111	90.2	2.8	125.5	14.0	113.8	13.2	225.5	121.0	4.8	112.8	124.6	13.4	112.8	125.9	13.4
18	185	108	90.5	2.7	123.9	13.6	113.9	12.9	234.5	121.0	4.6	117.2	126.0	12.7	117.2	125.3	12.8
19	192	114	89.7	2.5	124.2	12.8	114.7	12.0	244.8	119.0	4.5	122.4	125.7	12.4	122.4	122.7	12.4
20	185	109	94.3	2.6	123.0	13.3	114.9	12.5	235.3	120.0	4.6	117.7	123.3	12.9	117.7	122.3	13.0
21	150	117	98.3	2.9	122.2	15.1	114.6	14.3	213.9	121.0	5.3	107.0	121.1	14.2	107.0	123.0	14.2
22	178	106	100.7	2.8	123.4	14.3	114.6	13.5	226.9	118.0	5.0	113.4	120.8	13.6	113.4	123.4	13.7
23	164	88	95.6	3.1	123.0	15.9	114.7	14.9	201.4	119.0	5.7	100.7	120.8	15.4	100.7	123.5	15.5
24	171	100	99.1	2.9	121.7	14.7	114.7	14.4	217.1	120.0	5.3	108.5	120.2	14.5	108.5	123.1	14.6
25	178	129	96.5	2.6	121.7	12.7	114.8	12.3	245.1	114.0	4.6	122.5	120.4	12.6	122.5	123.3	12.7
26	179	103	98.5	2.8	121.9	14.3	114.0	13.0	225.6	119.0	5.1	112.8	120.4	13.9	112.8	123.8	13.9
27	178	107	98.1	2.7	122.3	14.6	113.8	13.2	228.3	117.0	5.0	114.1	121.4	13.8	114.1	124.3	13.8
28	150	96	98.2	3.2	123.1	16.5	114.3	15.0	197.2	120.0	5.8	98.6	122.2	15.7	98.6	125.3	15.7
29	137	92	98.2	3.4	123.5	17.5	114.5	16.4	183.4	119.0	6.4	91.7	122.6	17.1	91.7	126.0	17.1
30	157	89	98.4	3.2	124.7	16.2	114.7	15.3	197.1	119.0	5.7	98.6	123.4	15.5	98.6	126.3	15.6
Max	**192**	**129**	**100.7**	**3.7**	**125.5**	**18.6**	**114.9**	**17.6**	**245.1**	**121.0**	**6.7**	**122.5**	**126.0**	**18.1**	**122.5**	**127.3**	**18.2**
Avg	**169**	**101**	**93.0**	**2.9**	**122.8**	**15.1**	**112.9**	**14.1**	**216.5**	**118.8**	**5.3**	**108.2**	**122.7**	**14.3**	**108.2**	**124.5**	**14.4**
Min	**137**	**75**	**89.2**	**2.5**	**120.7**	**12.7**	**110.2**	**12.0**	**169.5**	**114.0**	**4.5**	**84.8**	**120.2**	**12.4**	**84.8**	**120.2**	**12.4**

Note:
Kgal/day: Kilo gallons per day
WAS: Waste Activated Sludge
HRT: Hydraulic Retention Time

Digester No.1: First Phase Mesophilic
Digester No.5: Third Phase Mesophilic
Digester No. 6 & 7: Second Phase Thermophilic

Blank Space: Data Not Available

TABLE V: Operational & Process Parameters (Contd.)

July	Dig #1				Dig #2		Dig #3		Dig #5			Dig #6			Dig #7		
2001	Sludge Primary Kgal/d	Sludge WAS Kgal/d	Temp °F	HRT days	Temp °F	Det. Time days	Temp °F	Det. Time days	Sludge From #6&#7 Kgal/d	Temp °F	HRT days	Sludge From #1 Kgal/d	Temp °F	HRT days	Sludge From #1 Kgal/d	Temp °F	HRT days
1	157	96	98.1	3.1	124.7	15.7	115.0	14.8	202.7	121.0	5.4	101.4	124.5	14.9	101.4	126.4	15.0
2	164	92	98.1	3.0	123.7	15.0	115.6	14.2	205.0	114.0	5.3	102.5	124.3	14.6	102.5	125.5	14.7
3	164	90	99.3	3.1	123.6	15.7	115.2	14.8	203.0	120.0	5.4	101.5	125.0	14.9	101.5	124.0	14.9
4	178	104	97.5	2.8	123.3	13.8	115.7	13.0	225.3		4.9	112.6	125.1	13.5	112.6	124.0	13.5
5	164	102	99.3	2.9	123.1	14.9	115.6	14.1	213.1	120.0	5.2	106.6	125.1	14.1	106.6	124.4	14.2
6	171	97	97.8	2.9	123.5	15.0	115.3	14.2	214.7	120.0	5.2	107.4	124.1	13.9	107.4	124.8	13.9
7	192	84	99.1	2.8	122.0	14.4	115.4	13.6	220.8	120.0	5.1	110.4	123.0	13.7	110.4	123.6	13.8
8	215	96	97.3	2.5	121.3	12.6	115.3	12.0	248.2	122.0	4.4	124.1	122.3	12.1	124.1	123.0	12.0
9	213	80	97.7	2.7	120.0	13.0	115.3	12.3	234.4		4.6	117.2	121.1	12.4	117.2	122.2	12.4
10	205	77	97.3	2.8	120.2	13.8	114.6	12.9	225.5	119.0	4.9	112.7	121.0	13.2	112.7	122.3	13.2
11	192	82	98.4	2.9	121.2	14.6	114.0	13.8	218.6	118.0	4.9	109.3	121.5	13.5	109.3	123.3	13.5
12	171	66	97.5	3.3	122.1	16.8	113.8	15.9	189.5	118.0	5.8	94.8	121.7	15.8	94.8	124.3	15.8
13	179	64	98.7	3.2	122.9	16.5	113.6	15.5	194.5	118.0	5.7	97.3	123.1	15.2	97.3	125.4	15.3
14	178	74	98.2	3.1	122.9	15.8	113.9	15.0	201.3	120.0	5.5	100.7	123.2	14.8	100.7	125.6	14.9
15	171	77	97.8	3.1	122.9	15.8	114.0	15.0	198.6	119.0	5.6	99.3	122.7	15.1	99.3	125.1	15.2
16	178	84	98.7	3.0	122.4	14.9	114.0	14.1	209.2	108.0	5.3	104.6	122.5	14.1	104.6	124.5	14.1
17	178	79	97.5	3.0	122.9	15.3	113.6	14.4	205.5	113.0	5.3	102.8	122.4	14.5	102.8	124.6	14.6
18	137	81	97.3	3.6	123.6	18.2	113.8	17.2	173.9	116.0	6.4	87.0	123.3	17.2	87.0	124.4	17.3
19	171	65	98.0	3.3	124.8	16.9	113.5	16.0	188.5	120.0	5.8	94.3	124.3	15.7	94.3	125.2	15.7
20	150	91	102.3	3.2	124.1	16.6	113.5	15.7	192.9	119.0	5.8	96.4	125.4	15.7	96.4	125.1	15.7
21	192	70	100.8	3.0	122.8	14.8	114.3	14.0	209.6	119.0	5.3	104.8	126.3	14.2	104.8	124.2	14.4
22	207	67	99.6	2.9	125.2	14.1	114.2	13.4	218.6	120.0	4.8	109.3	126.0	13.5	109.3	123.4	13.5
23	178	79	97.0	3.0	126.0	15.3	115.0	14.4	205.8	121.0	5.5	102.9	126.0	14.7	102.9	124.0	14.7
24	192	73	98.4	2.9	122.2	15.2	114.1	14.3	211.6	119.0	5.2	105.8	124.7	14.0	105.8	124.1	14.0
25	164	75	97.8	3.3	123.9	16.5	114.1	15.7	191.3	117.0	5.8	95.7	124.1	15.6	95.7	124.9	15.6
26	157	63	100.1	3.5	124.9	17.7	114.4	16.8	176.4	120.0	6.4	88.2	123.5	17.3	88.2	125.0	17.4
27	178	55	104.2	3.3	124.7	16.8	114.4	15.9	186.6	123.0	5.9	93.3	123.8	15.8	93.3	124.7	15.9
28	178	58	103.0	3.3	124.1	16.7	114.3	15.8	188.5		5.9	94.2	125.3	15.8	94.2	125.0	16.3
29	157	83	104.2	3.3	123.9	15.9	114.7	14.8	192.4	119.0	5.8	96.2	124.9	15.6	96.2	123.6	15.7
30	157	84	102.0	3.2	124.2	16.1	114.7	15.1	193.2	117.0	5.7	96.6	124.4	15.4	96.6	123.0	15.4
31	156	102	102.3	3.0	123.7	15.2	114.4	14.1	206.1		5.4	103.0	123.1	14.4	103.0	124.4	14.5
Max	**215**	**104**	**104.2**	**3.6**	**126.0**	**104.2**	**115.7**	**104.2**	**248.2**	**123.0**	**6.4**	**124.1**	**126.3**	**17.3**	**124.1**	**126.4**	**17.4**
Avg	**176**	**80**	**99.2**	**3.1**	**123.3**	**15.5**	**114.5**	**14.6**	**204.7**	**118.5**	**5.4**	**102.3**	**123.8**	**14.7**	**102.3**	**124.3**	**14.7**
Min	**137**	**55**	**97.0**	**2.5**	**120.0**	**12.6**	**113.5**	**12.0**	**173.9**	**108.0**	**4.4**	**87.0**	**121.0**	**12.1**	**87.0**	**122.2**	**12.0**

Note:

Kgal/day: Kilo gallons per day

WAS: Waste Activated Sludge

HRT: Hydraulic Retention Time

Digester No.1: First Phase Mesophilic

Digester No.5: Third Phase Mesophilic

Digester No. 6 & 7: Second Phase Thermophilic

Blank Space: Data Not Available

TABLE V: Operational & Process Parameters (Contd.)

Aug 2001	Dig #1				Dig #5			Dig #6			Dig #7		
	Sludge Primary Kgal/d	Sludge WAS Kgal/d	Temp °F	HRT days	Sludge From #6&#7 Kgal/d	Temp °F	HRT days	Sludge From #1 Kgal/d	Temp °F	HRT days	Sludge From #1 Kgal/d	Temp °F	HRT days
1	150	67	102.5	3.6	174.3	120.0	6.3	87.1	122.6	17.0	87.1	124.6	17.1
2	150	72	104.4	3.5	177.8	120.0	6.2	88.9		16.6	88.9	124.0	16.7
3	144	75	103.4	3.6	174.6	120.0	6.4	87.3		17.2	87.3	123.8	17.2
4	144	70	103.1	3.6	171.1	120.0	6.5	85.6	117.0	17.4	85.6	122.6	17.4
5	148	68	103.0	3.6	172.2	120.0	6.3	86.1	119.0	17.3	86.1	122.0	17.4
6	198	73	101.9	2.9	217.1	120.0	4.9	108.6	120.1	13.6	108.6	122.0	13.6
7	137	69	104.0	3.8	165.0	120.0	6.6	82.5	121.0	18.3	82.5	122.0	18.4
8	192	84	104.0	2.8	220.6	119.0	5.1	110.3	122.4	13.7	110.3	123.6	13.7
9	192	69	101.4	3.0	208.5	120.0	5.4	104.2	123.5	14.4	104.2	124.2	14.4
10	171	64	104.6	3.3	188.0	119.0	6.0	94.0	124.0	16.2	94.0	124.3	16.3
11	164	65	102.0	3.4	183.3	119.0	6.2	91.6	125.2	16.6	91.6	125.2	16.8
12	157	70	104.1	3.4	182.2	120.0	6.2	91.1	125.6	16.8	91.1	124.8	16.9
13	68	74	102.2	5.4	114.2	120.0	9.7	57.1	127.7	25.9	57.1	125.6	26.1
14	274	74	104.4	2.2	278.5	120.5	3.9	139.2	128.7	10.6	139.2	124.7	10.6
15	178	80	103.5	3.0	206.0	119.0	5.6	103.0	125.2	15.0	103.0	121.5	15.0
16	178	73	103.3	3.1	200.9	122.0	5.7	100.5	122.7	15.4	100.5	124.2	15.4
17	171	75	102.9	3.2	196.4	121.0	5.7	98.2	120.4	15.2	98.2	125.9	15.3
18	157	74	103.6	3.4	184.7	120.0	6.2	92.4	120.2	16.5	92.4	126.4	16.5
19	164	76	103.3	3.3	191.8	120.0	5.9	95.9	121.3	15.8	95.9	126.6	15.9
20	171	71	102.9	3.2	193.4		5.8	96.7	122.4	15.5	96.7	125.4	15.6
21	171	75	103.1	3.2	196.8	120.0	5.7	98.4	123.9	15.2	98.4	123.0	15.2
22	172	80	102.5	3.1	201.5	120.0	5.5	100.8	123.0	15.0	100.8	124.0	14.9
23	178	69	102.5	3.1	197.5	118.0	5.6	98.7	124.1	15.1	98.7	123.7	15.2
24	171	74	103.1	3.2	195.6	120.0	5.9	97.8	123.7	15.8	97.8	123.3	15.8
25	164	67	103.0	3.4	184.9	122.0	6.2	92.4	124.5	16.6	92.4	123.7	16.7
26	185	68	103.3	3.1	202.1	120.5	5.7	101.0	123.4	15.4	101.0	123.6	15.5
27	178	77	102.2	3.1	204.2		5.6	102.1	123.8	15.0	102.1	123.3	15.1
28	178	75	102.9	3.1	202.3	124.0	5.6	101.2	123.2	15.1	101.2	123.8	15.2
29	164	66	102.8		184.0	117.0		92.0	124.3		92.0	123.6	
30	178	67			195.8			97.9			97.9		
31	164	71			188.3			94.2			94.2		
Max	**274**	**84**	**104.6**	**5.4**	**278.5**	**124.0**	**9.7**	**139.2**	**128.7**	**25.9**	**139.2**	**126.6**	**26.1**
Avg	**168**	**72**	**103.1**	**3.3**	**192.1**	**120.0**	**5.9**	**96.0**	**123.1**	**16.0**	**96.0**	**124.0**	**16.1**
Min	**68**	**64**	**101.4**	**2.2**	**114.2**	**117.0**	**3.9**	**57.1**	**117.0**	**10.6**	**57.1**	**121.5**	**10.6**

Note:

Kgal/day: Kilo gallons per day
WAS: Waste Activated Sludge
HRT: Hydraulic Retention Time

Digester No.1: First Phase Mesophilic
Digester No.5: Third Phase Mesophilic
Digester No. 6 & 7: Second Phase Thermophilic

Blank Space: Data Not Available

TABLE V: Operational & Process Parameters (Contd.)

Sep 2001	Dig #1 Sludge Primary Kgal/d	Dig #1 Sludge WAS Kgal/d	Dig #1 Temp °F	Dig #1 HRT days	Dig #5 Sludge From #6&#7 Kgal/d	Dig #5 Temp °F	Dig #5 HRT days	Dig #6 Sludge From #1 Kgal/d	Dig #6 Temp °F	Dig #6 HRT days	Dig #7 Sludge From #1 Kgal/d	Dig #7 Temp °F	Dig #7 HRT days
1	178	61	102.6	3.2	199.3	123.0	6.1	99.6	124.3	16.3	99.6	123.8	16.4
2	164	77	103.7	3.2	200.9	121.0	5.9	100.5	123.6	15.9	100.5	123.5	16.0
3	171	66	103.4	3.3	197.6	122.0	6.0	98.8	124.0	16.0	98.8	123.9	16.1
4	178	62	103.9	3.2	200.2	123.0	5.9	100.1	123.6	15.8	100.1	123.8	15.8
5	178	87	102.7	3.0	220.6	124.0	5.4	110.3	123.8	14.4	110.3	123.1	14.6
6	164	66	101.8	3.4	191.8	122.0	6.1	95.9	123.6	16.4	95.9	123.5	16.5
7	157	67	103.1	3.5	186.8	120.0	6.4	93.4	124.2	17.1	93.4	124.2	17.3
8	157	57	103.6	3.6	179.0	123.0	6.5	89.5	123.3	17.5	89.5	123.8	17.5
9	178	64	102.0	3.2	201.8	123.0	5.7	100.9	123.5	15.4	100.9	123.9	15.5
10	178	65	103.5	3.2	202.6	115.0	5.8	101.3	123.3	15.4	101.3	123.2	15.5
11	192	53	103.9	3.2	203.9		5.6	102.0	123.4	15.5	102.0	123.3	15.5
12	192	66	102.1	3.0	214.7	119.0	5.5	107.4	122.8	14.6	107.4	123.0	14.6
13	178	62	102.4	3.2	199.9	118.0	5.9	99.9	123.4	15.8	99.9	124.0	15.9
14	171	109	103.4	2.8	233.5	120.0	5.2	116.7	124.0	13.8	116.7	123.5	13.9
15	164	49	102.7	3.7	177.7	121.0	6.7	88.9	123.5	18.0	88.9	123.6	18.0
16	178	63	103.2	3.2	200.5		5.8	100.2	123.8	15.7	100.2	123.9	15.9
17	192	64	102.1	3.0	212.9	118.0	5.5	106.5	124.1	14.7	106.5	123.5	14.9
18	192	55	103.9	3.2	205.3		5.7	102.6	123.8	15.3	102.6	123.8	15.3
19	192	49	102.7	3.2	200.6	116.0	5.8	100.3	123.3	15.6	100.3	123.9	15.8
20	164	55	103.5	3.5	182.9	115.0	6.5	91.5	123.7	17.4	91.5	123.9	17.4
21	157	54	103.0	3.7	176.1	115.0	6.7	88.0	123.5	18.0	88.0	123.6	18.2
22	164	63	99.6	3.4	189.0	120.0	6.3	94.5	123.0	17.0	94.5	123.2	17.0
23	137	63	103.0	3.9	166.4	120.0	7.1	83.2	123.3	19.1	83.2	123.3	19.1
24	150	66	101.4	3.6	180.0	118.0	6.5	90.0	124.4	17.4	90.0	123.7	17.5
25	157	71	99.7	3.4	190.4	117.5	6.2	95.2	124.1	16.6	95.2	123.6	16.6
26	157	76	102.5	3.3	194.0	117.0	6.0	97.0	124.1	16.2	97.0	123.9	16.2
27	157	65	103.5	3.5	185.5	118.0	6.3	92.7	124.1	16.9	92.7	123.3	16.9
28	157	59	102.9	3.6	180.0	119.0	6.6	90.0	123.9	17.6	90.0	123.7	17.7
29	150	73	103.6	3.5	186.1	119.0	6.3	93.1	123.4	17.0	93.1	123.3	17.1
30	130	70	103.6	6.0	167.0		10.9	83.5	123.6	29.1	83.5	123.5	29.2
Max	**192**	**109**	**103.9**	**6.0**	**233.5**	**124.0**	**10.9**	**116.7**	**124.4**	**29.1**	**116.7**	**124.2**	**29.2**
Avg	**168**	**65**	**102.8**	**3.4**	**194.2**	**119.5**	**6.2**	**97.1**	**123.7**	**16.7**	**97.1**	**123.6**	**16.8**
Min	**130**	**49**	**99.6**	**2.8**	**166.4**	**115.0**	**5.2**	**83.2**	**122.8**	**13.8**	**83.2**	**123.0**	**13.9**

Note:

Kgal/day: Kilo gallons per day
WAS: Waste Activated Sludge
HRT: Hydraulic Retention Time

Digester No.1: First Phase Mesophilic
Digester No.5: Third Phase Mesophilic
Digester No. 6 & 7: Second Phase Thermophilic

Blank Space: Data Not Available

TABLE V: Operational & Process Parameters (Contd.)

Oct	Dig #1				Dig #5			Dig #6			Dig #7		
2001	Sludge Primary Kgal/d	Sludge WAS Kgal/d	Temp °F	HRT days	Sludge From #6&#7 Kgal/d	Temp °F	HRT days	Sludge From #1 Kgal/d	Temp °F	HRT days	Sludge From #1 Kgal/d	Temp °F	HRT days
1	123	71	103.7	4.0	161.7	113.0	6.8	80.9	123.7	18.3	80.9	123.5	18.4
2	205	76	102.5	2.8	234.0		4.7	117.0	123.2	12.7	117.0	123.7	12.7
3	178	73	104.4	3.1	209.3	118.0	5.4	104.7	123.8	14.4	104.7	123.1	14.5
4	137	60		3.9	163.9	121.0	7.0	81.9	123.0	18.7	81.9	123.5	18.9
5	171	70		3.2	200.6	119.0	5.7	100.3	123.7	15.5	100.3	124.1	15.5
6	192	68	96.2	3.0	216.7	121.0	5.2	108.3	123.6	14.0	108.3	123.6	14.1
7	185	71	102.3	3.0	213.3		5.3	106.7	123.4	14.2	106.7	123.5	14.3
8	157	78	103.8	3.3	196.0	116.0	5.8	98.0	122.9	15.7	98.0	123.5	15.8
9	205	77	100.6	2.8	235.5		4.9	117.8	123.4	13.1	117.8	123.5	13.1
10	192	84	99.6	2.8	229.6	115.0	5.0	114.8	123.6	13.4	114.8	123.7	13.4
11	205	71	98.6	2.8	230.1	119.0	5.0	115.0	123.5	13.4	115.0	123.1	13.5
12	185	70	98.0	3.1	212.1	121.0	5.5	106.0	123.0	14.7	106.0	123.2	14.8
13	178	70	101.1	3.1	206.6	121.0	5.6	103.3	123.1	15.1	103.3	123.9	15.1
14	178	72	103.6	3.1	208.3	120.0	5.6	104.1	123.6	14.9	104.1	123.7	14.9
15	198	71	103.3	2.9	224.8	114.0	5.1	112.4	123.6	13.6	112.4	123.6	13.6
16	198	76	102.8	2.8	228.7		5.0	114.4	123.8	13.5	114.4	123.3	13.5
17	185	71	101.8	3.0	213.0		5.4	106.5	123.4	14.4	106.5	123.7	14.5
18	185	65	102.5	3.1	208.1	118.0	5.6	104.0	124.2	14.9	104.0	123.3	14.9
19	185	80	102.3	2.9	220.5	120.5	5.2	110.2	124.2	14.0	110.2	123.7	14.1
20	178	60	103.8	3.3	197.8	119.0	5.8	98.9	123.9	15.5	98.9	123.5	15.5
21	171	71	103.5	3.2	202.1	120.0	5.6	101.0	123.7	15.2	101.0	123.5	15.2
22	205	69	103.4	2.8	228.8	118.0	4.9	114.4	123.5	13.2	114.4	123.7	13.2
23	212	72	103.0	2.7	236.6	120.0	4.8	118.3	123.9	13.0	118.3	123.8	13.0
24	185	124	103.6	2.5	257.2	118.0	4.5	128.6	124.0	12.0	128.6	124.8	12.1
25	185	136	102.2	2.4	267.0	121.0	4.3	133.5	123.8	11.6	133.5	124.0	11.6
26	192	76	102.9	2.9	222.6	119.0	5.2	111.3	122.7	14.0	111.3	123.3	14.0
27	178	68	103.0	3.2	204.7	121.0	5.7	102.4	123.5	15.2	102.4	123.8	15.3
28	205	63	102.4		223.4	120.0		111.7	123.9		111.7	123.5	
29	192	68			216.0			108.0			108.0		
30	205	70			229.3			114.7			114.7		
31	192	69			217.0			108.5			108.5		
Max	**212**	**136**	**104.4**	**4.0**	**267.0**	**121.0**	**7.0**	**133.5**	**124.2**	**18.7**	**133.5**	**124.8**	**18.9**
Avg	**185**	**75**	**102.1**	**3.0**	**216.6**	**118.8**	**5.4**	**108.3**	**123.6**	**14.4**	**108.3**	**123.6**	**14.4**
Min	**123**	**60**	**96.2**	**2.4**	**161.7**	**113.0**	**4.3**	**80.9**	**122.7**	**11.6**	**80.9**	**123.1**	**11.6**

Note:

Kgal/day: Kilo gallons per day
WAS: Waste Activated Sludge
HRT: Hydraulic Retention Time

Digester No.1: First Phase Mesophilic
Digester No.5: Third Phase Mesophilic
Digester No. 6 & 7: Second Phase Thermophilic

Blank Space: Data Not Available

TABLE V: Operational & Process Parameters (Contd.)

Nov	Dig #1				Dig #5			Dig #6			Dig #7		
2001	Sludge Primary Kgal/d	Sludge WAS Kgal/d	Temp °F	HRT days	Sludge From #6&#7 Kgal/d	Temp °F	HRT days	Sludge From #1 Kgal/d	Temp °F	HRT days	Sludge From #1 Kgal/d	Temp °F	HRT days
1	205	68	103.1	2.9	227.4	121.0	5.1	113.7	123.6	13.7	113.7	123.4	13.8
2	171	76	103.6	3.2	206.0		5.8	103.0	124.4	15.4	103.0	123.8	15.4
3	178	57	102.5	3.3	196.0	121.0	5.9	98.0	124.2	15.8	98.0	123.6	15.9
4	219	71		2.7	241.8	119.0	4.7	120.9	123.9	12.8	120.9	123.4	12.8
5	219	76		2.6	245.5	115.0	4.7	122.8	123.3	12.6	122.8	123.7	12.7
6	178	72	102.2	3.1	208.5	118.0	5.6	104.3	123.5	15.0	104.3	123.7	15.0
7	157	113	102.9	2.9	225.2		5.2	112.6	123.7	13.9	112.6	123.5	14.0
8	171	77	102.6	3.1	207.0	119.0	5.7	103.5	123.4	15.1	103.5	123.5	15.1
9	178	82	102.9	3.0	216.3		5.4	108.1	122.9	14.4	108.1	123.6	14.5
10	150	64	99.6	3.6	178.9	119.0	6.5	89.5	123.9	17.4	89.5	123.7	17.5
11	137	132	98.6	2.9	223.8		5.1	111.9	124.0	13.7	111.9	123.7	13.8
12	144	72	103.2	3.6	179.7		6.3	89.9	123.5	17.0	89.9	123.8	17.0
13	164	80	102.7	3.2	203.6	120.5	5.5	101.8	124.1	14.8	101.8	123.9	14.8
14	171	97	102.3	2.9	223.4	119.5	5.0	111.7	123.5	13.5	111.7	123.5	13.5
15	178	83		3.0	228.1	120.0	4.9	114.1	123.5	13.2	114.1	123.6	13.2
16	178	91	99.2	2.9	235.1		4.8	117.6	123.5	12.9	117.6	124.2	13.0
17	192	72	102.8	3.0	231.0		4.9	115.5	123.8	13.2	115.5	123.7	13.2
18	171	84	102.4	3.1	222.8	120.0	5.1	111.4	123.0	13.5	111.4	124.0	13.6
19	192	75	104.0	2.9	233.5	116.0	4.8	116.8	123.1	12.9	116.8	123.1	12.9
20	192	80	102.6	2.9	237.8		4.7	118.9	123.1	12.6	118.9	123.3	12.7
21	185	88	102.8	2.9	238.6	116.0	4.7	119.3	123.4	12.6	119.3	123.1	12.7
22	157	87	101.9	3.2	213.6	120.0	5.4	106.8	123.5	14.4	106.8	122.9	14.5
23	178	86	101.4	3.0	230.4	119.0	5.0	115.2	123.7	13.4	115.2	124.0	13.4
24	205	38	102.2	3.2	213.1	120.0	5.4	106.5	123.0	14.4	106.5	122.8	14.4
25	198	97	101.6	2.6	258.3	120.0	4.6	129.1	121.6	12.3	129.1	122.5	12.3
26	192	90	101.4	2.8	246.7	118.0	4.8	123.4	121.9	12.8	123.4	123.2	12.8
27	198	94	103.2	2.7	255.5		4.6	127.8	119.8	12.4	127.8	121.6	12.4
28	192	86	101.0	2.8	242.8	116.0	4.8	121.4	121.3	13.0	121.4	121.9	13.1
29	164	108	100.1	2.9	237.9	121.7	4.9	118.9	121.7	13.2	118.9	121.8	13.2
30	185	87	102.1	2.9	237.3	116.0	5.0	118.7	122.1	13.3	118.7	121.4	13.4
Max	**219**	**132**	**104.0**	**3.6**	**258.3**	**121.7**	**6.5**	**129.1**	**124.4**	**17.4**	**129.1**	**124.2**	**17.5**
Avg	**180**	**83**	**102.0**	**3.0**	**224.9**	**118.8**	**5.2**	**112.4**	**123.1**	**13.8**	**112.4**	**123.3**	**13.9**
Min	**137**	**38**	**98.6**	**2.6**	**178.9**	**115.0**	**4.6**	**89.5**	**119.8**	**12.3**	**89.5**	**121.4**	**12.3**

Note:

Kgal/day: Kilo gallons per day

WAS: Waste Activated Sludge

HRT: Hydraulic Retention Time

Digester No.1: First Phase Mesophilic

Digester No.5: Third Phase Mesophilic

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Blank Space: Data Not Available