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Scale-Up Analysis of Enviro-Flo NuWater BNR 500 to BNR 600 Pursuant to NSF/ANSI Standard 40 (2012)

GCT Project SPE198

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TABLE OF CONTENTS

TABLES

APPENDICES

INTRODUCTION

This engineering analysis and review was conducted on the field tested Enviro-Flo, Inc. NuWater BNR 500 treatment unit (500 gallons per day treatment capacity) to analyze if a proposed change to scale-up to a NuWater BNR 600 unit (600 gpd capacity) meets NSF/ANSI Standard 40 (2012). Section 1.4 of Standard 40 (2012) states the following:

> Performance classification
>
> For the purpose of this Standard, systems are classified according to the chemical, biological, and physical characteristics of their effluents as determined by the performance testing and evaluations described herein.
>
> All systems within a manufacturer's model series may be classified according to the performance testing and evaluation of the system with the smallest hydraulic capacity within the series. Performance testing and evaluation of larger systems within the series (having hydraulic treatment capacities within the scope of this Standard) may not be necessary provided that the dimensions, hydraulics, mixing and filtering capabilities, and other applicable design characteristics are proportionately equivalent to the evaluated system.

HISTORY

The NuWater BNR 500 unit was originally tested by Gulf Coast Testing, LLC at a flow rate of 500 gallons per day starting on April 18, 2010 and ending November 6, 2010. The final report including appendices is included as Appendix A. The test was successfully completed and the unit was certified to NSF/ANSI Standard 40 on February 1, 2011. The unit is currently listed on GCT's website as approved for Standard 40.

PROPOSED CHANGE

It has been requested that this 500 gallon per day unit be upgraded and approved pursuant to NSF/ANSI Standard 40 (2012) for a scale-up to treat 600 gallons/day. The original unit was constructed in concrete and used an HP60 aerator. The new 600 gpd unit will concrete with a similar geometric shape. The new unit would use an HP60 aerator or an HP80 aerator. The drawing for the proposed mold for the NuWater BNR 600 tank is included in Appendix B.

COMPARISON OF COMPARTMENT GEOMETRY AND SIZING

The Enviro-Flo, Inc. NuWater BNR 500 unit as tested is composed of three (3) compartments, Pretreatment, an Aeration Reactor compartment, and a Clarification compartment. The aeration reactor compartment, where a majority of the biological activity takes place, has a cited volume of 447 gallons (approximately 60 cubic feet).

This volume would provide a hydraulic retention time (HRT) of approximately 21.5 hours at a flow rate of 500 gallons per day. The air is pumped into the aeration compartment via a mechanical blower and diffuser arrangement. The air is releases into the aeration compartment and the mixing velocities assist the sludge to be returned from the clarification section. The aeration volume is sufficient to be classified as an extended aeration process. The treatment unit has a cited clarifier volume of approximately 160 gallons (approximately 21.4 cubic feet). This volume yields a detention time for settlement of approximately 7.7 hours. The clarification compartment is shaped with a rectangular top and straight side walls with a sloped floor which allows the settled solids to return to the aeration compartment. All volumes are calculated using the invert of the discharge pipe from the separation compartment discharge. An air lift pump is used on a timer basis to return a portion of the settled sludge back to the pretreatment compartment. The timer operates twenty three hours per day supplying air to the aeration chamber and one hour per day to return the settled sludge back to the pretreatment compartment. This compartment has a calculated volume of 320 gallons (HRT of 15.4 hours).

The Enviro-Flo Model BNR Wastewater Treatment System produced an effluent that successfully met the performance requirements established by NSF/ANSI Standard 40 (2012) for Class I effluent. During the first month of the evaluation, the maximum 7-day arithmetic mean was 7 mg/L for $CBOD_5$ and 9 mg/L for suspended solids, both below the allowed maximums of 56 and 63 mg/L respectively. The 30-day arithmetic mean during the first month of testing was 6 mg/L for $CBOD_5$ and 7 mg/L for suspended solids, both below the allowed maximums of 35 and 42 mg/L respectively.

During the final five months of the evaluation, the maximum 7-day arithmetic mean was 8 mg/L for $CBOD_5$ and 8 mg/L for suspended solids, both below the allowed maximum of 40 and 45 mg/L respectively. The maximum 30-day arithmetic mean was 6 mg/L for $CBOD_5$, below the allowed maximum of 25 mg/L. The maximum 30-day arithmetic mean was 6 mg/L for suspended solids, below the allowed maximum of 30 mg/L.

The effluent pH during the entire evaluation ranged between 6.69 and 7.18, within the required range of 6.0 to 9.0. The plant met the requirements for noise levels with less than 60 dbA at a distance of 20 feet in four different directions, as well as the requirements for color, threshold odor, oily film and foam.

The NuWater BNR 600 unit is a conventional activated sludge-extended aeration process with a pretreatment tank with a similar construction to the BNR 500.Table 1 of this report compares the originally tested 500 gpd model with the proposed 600 gpd model. The HRT of the aeration compartment (21.9 hours) is within the range of the cited values for the extended aeration process in the Engineering Manual of Practice No.8 (MOP-8) and an increase of 22.4% over the tested 500 gpd unit. The clarification system of proposed unit has a larger clarification compartment when compared to the originally tested unit. The NuWater BNR 600 clarification chamber is 35.6% larger than the tested 500 gpd unit. The pretreatment tank is 20% larger than the tested unit.

Thus, for an increased treatment flow rate of 20% (500 vs 600 gpd), the compartment volumes of the NuWater BNR 600 unit have been adequately increased in volume and are sufficient to handle the additional loading to meet Standard 40.

Table 1
Compartment Volume Comparison

	Originally Tested 500 gpd Unit		Proposed 600 gpd Unit		Percentage Change
Compartment	Volume, gals	HRT, hrs	Volume, gals	HRT, hrs	%
Pretreatment	320	15.4	383	15.3	19.7
Aeration	447	21.5	547	21.9	22.4
Clarification	160	7.7	181	8.7	35.6

AERATION CAPABILITY

The NuWater BNR 500gpd treatment unit was tested and approved with a HP-60 blower unit. Based on the performance curves, this blower will produce 2.43 cubic feet per minute (cfm) of air at a pressure of 1.8 psi with an operating water depth of 50.0 inches. Therefore, the upgraded unit needs a minimum 20% increase in aeration capacity (2.92cfm) to match the flow increase to achieve similar results of to the BNR 500 of an effluent BOD and TSS of 5 mg/l and an effluent NH3-N of 2 mg/l.

An HP-80 will provide 3.1 cfm at an operational water depth of 51 inches (1.84 psi) in the NuWater BNR 600 unit. This is 28% increase and is greater than the desired aeration capacity needed for the increased flow rate. The area of the openings in the diffuser bar should also be increased by 20%. These oxygen calculations are based on an effluent BOD and TSS of 5 mg/l and an effluent NH3-N of 2 mg/l.

However, if the NuWater BNR 600 unit is applied to site-specific applications where the effluent requirements are less stringent, then a lower oxygen requirement would be required.. The more stringent effluent parameters of 5/5/1 (BOD/TSS/NH3-N) would have a calculated Actual Oxygen Requirement of 0.072 lbs O_2/hour. When utilized for the less stringent effluent parameters of Standard 40 or 25/30 (BOD/TSS), the NuWater BNR 600 gpd treatment unit would only have a calculated Actual Oxygen Requirement of 0.0727 lbs O_2/hour. Therefore, under such effluent criteria, the NuWater BNR 600 gpd treatment unit could utilize the same blower as the tested 500 gpd unit. More stringent limits beyond the Standard 40 requirements could also be met by the 600 gpd unit, but the dissolved oxygen level in the aeration tank would be reduced.

CONCLUSION

Based on the engineering reviews and analysis conducted on the NuWater BNR 500gpd treatment unit and the NuWater BNR 600 gpd treatment unit, we offer the following comments and conclusions:

- The NuWater BNR 500 gpd treatment unit was fully tested and shown to be in conformity with the guidelines and procedures established by NSF/ANSI. The unit was certified to be in compliance with ANSI/NSF Standard 40 on February 1, 2011. This unit had pretreatment volume of 320 gallons, an aeration volume of approximately 447 gallons and a clarifier volume of approximately 160 gallons. The unit achieved an average BOD of 5 and an average TSS of 5 over the duration of the test.

- As allowed by NSF/ANSI Standard 40, the NuWater BNR 500gpd treatment unit was analyzed for a change in flow rate to 600 gpd. The NuWater BNR 600 gpd unit has a pretreatment volume of 383 gallons, an aeration volume of 547 gallons and a clarification volume of 217 gallons. This scale-up is sufficient to meet the additional flow rates.

- The NuWater BNR 600 gpd treatment unit would use an HP-80 aerator to provide the proper amount of aeration to realize similar effluent values (5 BOD/5 TSS) achieved by the BNR 500.

- The NuWater BNR 600 gpd treatment unit could utilize the HP-60 aerator and still meet the effluent criteria of Standard 40.